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State of the Art of Textile Waste Treatment

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16. Abstract

Waste treatment methods and practices used in the Textile industry have been studied. The literature was reviewed and an annotated bibliography prepared to supplement the information obtained from people working in the textile processing industry, designing waste treatment plants, and enforcing state and federal regulations on waters discharged to streams and natural reservoirs. Information was given on: characteristics of textile waste, waste treatment techniques, treatment methods in use, effects of textile wastes on receiving waters, the cost of waste treatment operations, and state and federal regulations governing discharge waters. More research is needed on desizing, removal of dyes from textile wastes, electrolytic treatment of textile waste, space requirements of waste treatment plants, reverse osmosis, sludge handling and disposal, water reuse in textile plants, total carbon analysis, mixing of textile and domestic waste, pilot plants, ~~and~~ a cooperative pollution abatement organization for the textile industry should be formed. (Smith-Texas)

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STATE OF THE ART OF
TEXTILE WASTE TREATMENT

A STUDY CONDUCTED FOR

WATER QUALITY OFFICE
ENVIRONMENTAL PROTECTION AGENCY

BY

DEPARTMENT OF TEXTILES
CLEMSON UNIVERSITY
CLEMSON, SOUTH CAROLINA 29631

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ABSTRACT

A study has been made of waste treatment methods and practices used in the textile industry. Information was obtained from people working in the textile processing industry, designing waste treatment plants, and enforcing state and federal regulations on waters discharged to streams and natural reservoirs. To supplement this information the literature was reviewed and an annotated bibliography prepared using relevant articles.

The report contains sections on the following: characteristics of textile waste, waste treatment techniques, treatment methods in use, effects of textile wastes on receiving waters, the cost of waste treatment operations, and state and federal regulations governing discharge waters.

Areas of needed research are recommended to improve waste treatment methods currently practiced by the textile industry.

The report is designed to give the reader an insight into the problems facing the textile industry, solutions presently available, and references for further reading.

The annotated bibliography contains references on synthetic fiber manufacturing wastes, detergent waste treatment, instrumentation, plant design, water treatment for plant use as well as articles pertaining specifically to textile waste treatment.

This report was submitted in fulfillment of Grant project 12090 ECS between the Federal Water Quality Administration and Clemson University

Key Words: Textiles, Wastewater Treatment, Industrial Wastes, Cost Comparisons.

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RECOMMENDATIONS AND CONCLUSIONS

Areas of Needed Research

Desizing

Research is needed which will decrease significantly the waste load from desizing operations. This may be accomplished by recovering the size from the waste stream for reuse or developing more rapid treatment methods for size removal.

The waste water from a desizing operation constitutes one of the biggest BOD loads on the treatment plant (1). If the sizing polymer is biodegradable, as is starch, the treatment plant has to have available sufficient volume capacity for the retention and oxidation of the waste. However, if the sizing material is not biodegradable, such as polyvinyl alcohol or carboxymethyl cellulose, (2) the system will not degrade these polymers and may not remove them from the waste stream.

The alternative methods of removing soluble refractory polymers from waste streams are by physical or chemical treatment. Pangle has received a patent (3) for the removal of textile chemicals from wastewater by treating the waste with calcium oxide and carbon dioxide. This method could be applied to CMC removal. In this case the crosslinking of polymer chains by salt bridges would cause their precipitation and eventual removal. Other multivalent cations would be used and might be more effective. The problem is more complex with polyvinyl alcohol, which is a neutral polymer. Its removal might be accomplished by absorption (4) or molecular filtration, but either of these methods will require laboratory work to prove their applicability. Since the use of this polymer is increasing each year, a research effort is needed to determine its eventual fate in the waste streams.

One method of removing desizing chemicals from the waste stream is to use sizing polymers that can be recovered and reused. If new sizes are developed that can be applied and recovered from solvent systems, the size load on the waste stream would be eliminated. Some of the major polymer manufacturing companies are looking at this, but no commercial use is presently underway. Other properties could be built into the sizing chemicals to increase their usefulness - dyeability, permanent press, and soil resistance. By taking a broad view of the possibilities available to the sizing operation many changes are discernible in textile finishing.

Removal of Dyes from Textile Waste

Research is needed which will demonstrate the effective and economical removal of color from textile waste streams.

The removal of dyes from textile waste streams is important because their contamination is visible. The approximate quantity of dye waste produced per year may be estimated from the curves in Figure I which show that 10 billion lbs. of fibers are currently processed by the textile industry per year. Although some fabrics are not dyed, others receive as much as 6 percent dye. If we use 1% dye as a conservative average, 100 million pounds of dye are consumed by the American textile industry per year. As about 10 percent of this ends up in the waste stream, 10 million pounds of dye per year must be treated by textile waste treatment plants. Treatment methods that have been used for dye containing waste streams are in most cases biological. Whether or not this method of treatment is the most suitable is debatable and is the basis for much needed research.

Recent studies have shown that biological treatment methods can degrade selected dyes (5), but the degradation products may be more toxic than the dyes themselves. Other reported data (2) show several dye systems to be resistant to degradation. No doubt the high standards placed on commercial dyes to resist many chemical environments such as washing and fading suggest that most of them will either be resistant to biological degradation or require carefully controlled conditions for microbial treatment. Better and less sensitive methods of dye removal may be accomplished by physical or chemical treatment. These include polymer coagulation (6), cation ion precipitation (7), carbon adsorption (8), ion exchange(9), and high energy radiation (10). The cost of these methods may be more than that of conventional biological treatment systems, but the fact that some are in commercial operation (8) shows that they are practical.

Research that is needed will establish parameters for the effective and economical operation of chemical treatment and show clearly how it can complement existing biological treatment plants. The analytical procedures used in the research projects will be important because BOD tests will not measure refractory chemicals. The fact that dyes can be degraded to objectionable, colorless toxic moieties (5) is more reason for the use of extensive analytical procedures in the evaluation of any treatment method. Gas chromatographic, mass spectral, total carbon and infrared analyses, or other quantitative methods should be used to show the presence of trace amounts of materials in treated waste streams.

Electrolytic Treatment of Textile Waste

Electrolytic methods of waste treatment must be examined more closely as a means of removing the refractory chemicals present in the textile waste streams today.

A patent was recently issued (11) for a system which will remove color from a textile waste stream by electrolysis. It was claimed that hypochlorite generated during electrolysis degrades dyestuffs. One disadvantage noted was the requirement of sufficient chloride ion concentration for suitable conductivity and hypochlorite production.

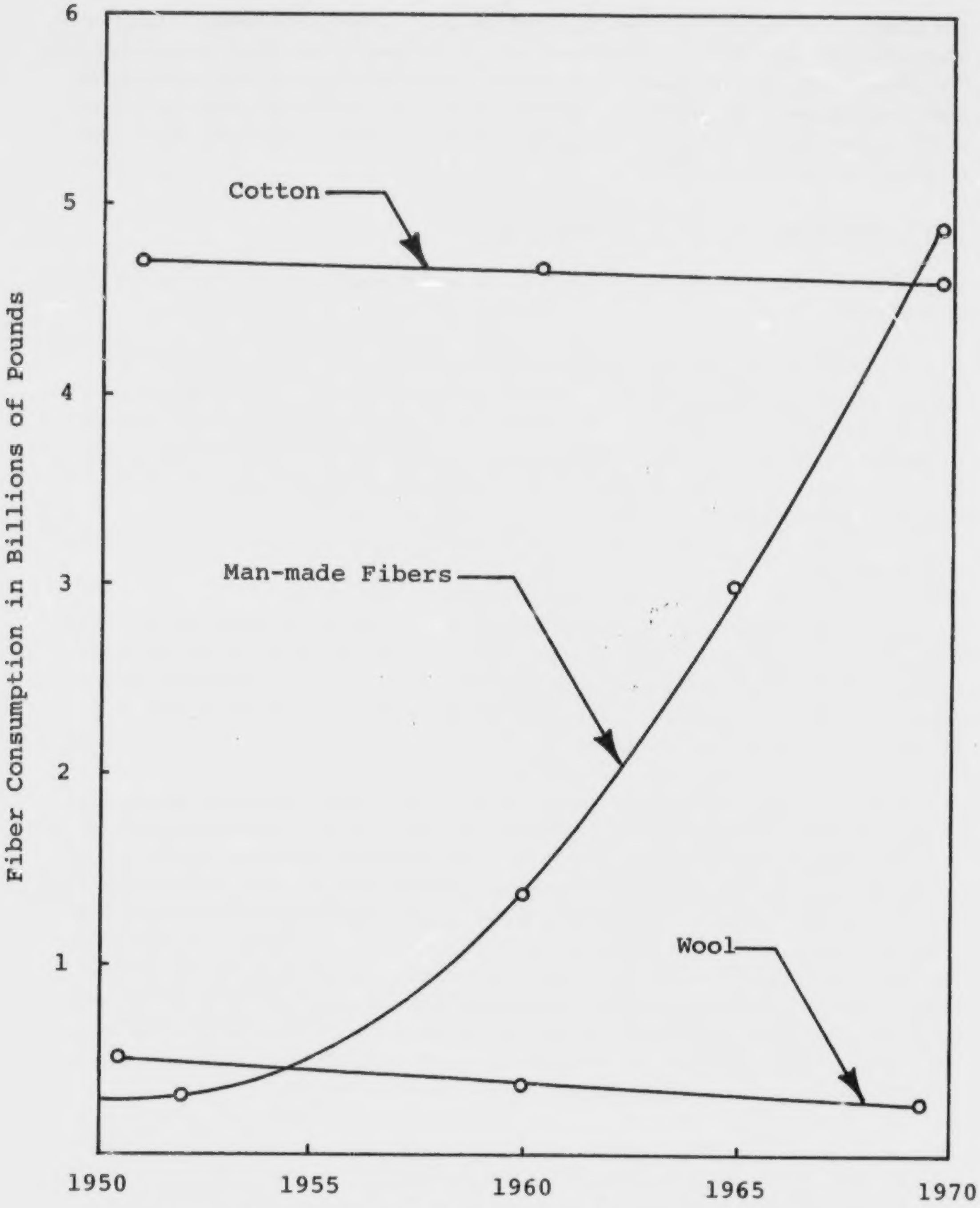

Figure 1. Consumption of Textile Fibers in the United States (Textile Organon, 40, 191 1969).

The process is attractive for other applications such as reducible metals removal and electrodialytic separations. Additional work is needed to determine how to optimize the process and lower the power consumption. For the process to have the greatest chance of success it should be incorporated in an overall treatment plan for use on waste streams requiring special treatment such as dye waste, refractory chemicals, or chromium containing effluents.

Space Requirements of Waste Treatment Plants

Research is needed to reduce significantly the space required for biological treatment systems.

Space required for modern biological waste treatment plants is large (12). The obvious reason for this is the retention time necessary for biological degradation of industrial effluents. Although space has not been a limiting factor in the South, it has been limiting in highly populated areas of the North. The time is not very far away when we will not be able to refer to a waste treatment plant as being "As big as a City" (12).

Reverse Osmosis

Reverse osmosis deserves more research attention to establish its applicability to the treatment of textile waste. The fact that water can be produced which would be suitable for reuse makes the process attractive. Any research study should also propose an effective method to dispose of the waste concentrate which will be a by-product of this type of treatment.

The textile industry uses a large amount of salt, ionic dyes, inorganic catalyst, detergents and bleaching agents that add to the dissolved solids concentration of the waste water. Some of these electrolytes are nutrients which are partially removed by conventional biological treatment plants; however, most of them pass into the receiving stream. As industry grows the concentration of dissolved solids in natural waters will increase unless corrective measures are taken. Initial action has been taken by some local government agencies in specifying maximum allowable dissolved soild concentrations in wastewaters. The next step will be enforcement and constant re-evaluation of regulations to be sure that suitable limits have been determined. The changes in regulations will come about as the population density changes and the industrial community increases in size.

One of the more effective methods which have been recently developed for electrolyte removal is reverse osmosis (13). The process utilizes the lower permeability of solvated ions (non-electrolytes can also be removed) across polymer membranes to remove them from a water solution. In most cases reverse osmosis has been applied to water treatment in areas where natural water supplies were contaminated or highly saline. The initial studies show the process to be an expensive method of purifying water for human consumption; however, in industrial water treatment where the level of treatment required may be lower, the process could be more economical.

Sludge Handling and Disposal

Research is needed to develop effective and economical methods for ultimate disposal of concentrated waste materials removed from wastewaters. Attention should be given to recovery and reuse of chemicals, both to minimize production costs and to reduce disposal problems. Ultimate disposal of waste concentrates must be made in ways which do not cause more pollution problems.

Existing biological waste treatment plants processing textile finishing wastes have a real problem of handling excess sludges. In the past land fills and spreading on the soil have been the most common methods of disposal. These are becoming expensive and can result in water pollution. Seepage from land fills can pollute ground water or surface water. If drainage from fields on which sludge has been spread goes directly to streams, heavy rains can wash the sludge into these surface waters. Better methods of dewatering and disposing of these sludges are needed. Incineration is a possibility, but air pollution problems should be considered.

Water Reuse

When requirements for quality of wastewater discharges approach requirements for process water, it becomes feasible to consider water renovation and reuse within the mill. Some physical-chemical methods result in high quality water. Use of such treatment methods or tertiary treatment after conventional processes may well be economical in some cases. The philosophy of closing the loop and entirely eliminating effluents seems to be gaining ground, possibly as a response to periodic tightening of regulations.

In-Plant Changes

Mention has been made of process changes which have reduced BOD of wastewater. Deliberate efforts are needed to minimize water consumption per unit of production. Not only is a savings in water costs possible, but also a reduction in the hydraulic load to the waste treatment facility may allow for smaller units requiring less capital and operating costs. Employees need to know about the costs involved in water supply and waste disposal. Mill management must also recognize these costs as part of production expenses, and encourage, from the top, the good housekeeping practices and water savings which reduce the costs of waste treatment and disposal.

Total Carbon Analysis

To get an accurate measure of the organic compounds present in a waste stream, a total carbon analysis of the waste stream is useful. A BOD test will only measure biological oxidation. It gives no indication of the presence of nondegradable materials. The BOD test is useful in designing aeration capacity for biological treatment plants, but it gives no indication of refractory organic compounds in treated effluents. Carbon analysis is not affected by toxicity, source and acclimation of seeding organisms, dilution water, and other chemical interferences which can cause problems with the BOD determination. Automated equipment is available to measure continuously and record carbon content in wastes or process streams where continuous control becomes important (14). Even with standard equipment data from carbon analyses are available within an hour after sample collection compared to five days for BOD determinations.

Mixing of Textile and Domestic Waste

A research committee of the American Association of Textile Chemists and Colorists has published a list of textile chemicals which gives the 5 day BOD of each chemical (2). Out of 300 products, almost 40% had less than a 10% 5 day BOD by weight of chemical and may be considered relatively resistant to biodegradation.

The use of synthetic fibers, polymers, and finishes by the textile industry is increasing at a rapid rate. Since many of these products are resistant to biological degradation, a careful study of their removal from wastewaters is essential so that effective waste treatment methods are chosen. Both State and Federal regulations will increase as the industrial community grows and the water supply is reused more often. Although mixing of domestic wastes with textile wastes has led to successful treatment in the past (15), the increasing inertness of textile effluents may prevent this general approach in the future.

Two important considerations for the construction of a waste treatment plant are the cost and availability of land. As waste chemicals become harder to degrade biologically, longer retention times will be needed for their degradation in the treatment plant. Plant size, therefore, is dependent on the character of the waste stream. Chemicals that are resistant to biodegradation may be removed from the stream by adsorption on the sludge formed by biological degradation. In some cases this method of removal will be satisfactory, but more data is needed to substantiate the effectiveness of adsorption on sludge as a removal process.

In the future, waste streams from different processing operations will have to be isolated and treated by either physical, chemical, or biological methods, or by combinations of these methods. The choice of treatment will depend on the composition of the waste stream. Effluent through a single pipe can no longer simply be "turned over" to the pollution control engineer for him to "take care of."

The Use of Pilot Plant and Laboratory Data for Plant Design

One of the hardest problems the engineer faces is designing a full scale plant from plant laboratory data. To design plant scale lagoons, aerators, clarifiers, filters, etc., requires appropriate "scale-up" factors and often experience with the specific waste stream.

It is therefore recommended that the study be undertaken to correlate the existing information on such things as α coefficients (relative rates of oxygen transfer to waste and water), and β coefficients (aerator spacing correction), so that more economical waste treatment plant design will be possible with less guesswork. This may be a difficult undertaking, but it is very important to waste treatment plant design. The cost of a waste treatment plant may be the factor which determines whether or not a textile plant can continue to operate. It is therefore very important that the most economical construction be chosen.

Any data that guides the engineer to the most accurate specifications of equipment and layout will result in an eventual savings to the industry which is installing the waste treatment plant. One approach to this research would be to design treatment plants with flexibility enough to take care of future changes in production. An example of this is the use of concrete trickling filters for a specific textile waste containing starch when the textile industry is changing from the biodegradable starch to the relatively inert polyvinyl alcohol. Treatment plant design must be done with a consideration for these changes, or a financial loss will result when existing treatment facilities become unuseable.

Formation of a Cooperative Pollution Abatement Organization for the Textile Industry

There is a need for an industry organization to cooperatively explore treatment process and other pollution control improvements. A real need and opportunity exist for a textile-related organization comparable to the National Council for Air and Stream Improvement affiliated with the pulp and paper industry. This organization could explore possible improvements in pollution abatement for the textile industry as a whole.

Such an organization could have several functions:

In-house research and development
Pilot Plant studies
Research support at universities or foundations
Public relations
Information collection, storage, and retrieval

The organization should be free enough to effectively pursue problems of greatest significance, yet insulated enough from competition between firms so that it would function effectively. Support would probably come from contributions from member firms with some agreement on the ratio of support to membership. Open disclosure should be encouraged where applicable, but there should be some advantages to the supporting firms, else there is little likelihood of support. Actual structure and administration could best be formulated by exchange of ideas through ATMI or one of its committees.

The organization should have a small full time staff and should seriously consider the experience of the National Council for Air and Stream Improvement as an example of the advantages and problems resulting from such cooperative action.

Since most mills do not have a specialist in waste treatment, there is a very real likelihood that even though information may already be available for the solution of problems, local personnel may have no contact with the information or its source. A cooperative organization could compile, abstract, and distribute the available information. It could also serve as a search agency when specific information is requested by one of the members.

Such an organization could advance pollution abatement considerably at minimal cost. Pilot plant studies which have general applicability could be run at one location rather than repeated by several firms. Cooperative support of research and development should return more information to each member firm at less cost than individual effort.

INTRODUCTION

The public knowledge of the potential threat that pollution poses to our environment has made us aware that some changes must be made if we are to continue to enjoy our environment. Since the harm any specific case of pollution may cause is dependent on the total pollution, we must first look at this to put the problem in its proper perspective. An idea of the total potential pollution may be gained from the curve shown in Figure 2, where the Gross National Product and population are plotted from 1930 to the present time. While population has almost doubled over the past 40 years the GNP has increased by a factor of 10 to 20, depending on the inflationary yardstick chosen. Since GNP is the combined measure of goods and services both of which can contribute to pollution, it should be proportional to the total industrial waste effluent that needs treatment. One estimate is that 1/4 of the total available run-off water is being used today by all industry and in fifty years the water usage will equal the available run-off water.

As of 1968 approximately 14.3 trillion gallons of water are discharged by the U. S. industry each year (16). The textile mill products* industry discharged about 461 billion gallons or 1% of the total. The major water users are:

Metal & Metal Products	7,841	Billion Gals/yr	22.1%
Chemical & Allied Products	7,820	"	22.0%
Paper & Allied Products	6,599	"	18.6%
Petroleum & Coal Products	7,220	"	20.3%
Food & Kindred Products	1,405	"	4.0%
Textiles Mill Products	1,127	"	3.2%
Rubber & Plastics	1,106	"	3.1%
Other	2,438	"	6.7%
Total	35,556		100.0%

There are approximately 4 million employees working in textile related jobs. Of these, nearly 1 million may be considered textile employees working for 700 mills with an annual sales of 21 billion dollars (16).

Another very important factor to consider as far as the textile industry is concerned is the rate at which this growing waste stream is changing in composition. Some evidence for this is seen in the data reported in Figures 3 and 4. New detergents and resins which are introduced onto the textile market are generally accompanied by a new or different effluent. A waste stream that may have once been homogeneous and biodegradable can become heterogeneous and inert. It is evident that we must have waste treatment plants with built in flexibility so they can accommodate future production changes. This is hard to do when the industrial waste stream is treated by a municipal treatment plant. In some cases the mixing of industrial and municipal

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* Includes the SIC Industry Group Numbers 221-223, 225-229, and Industry Numbers 2823 and 2824.

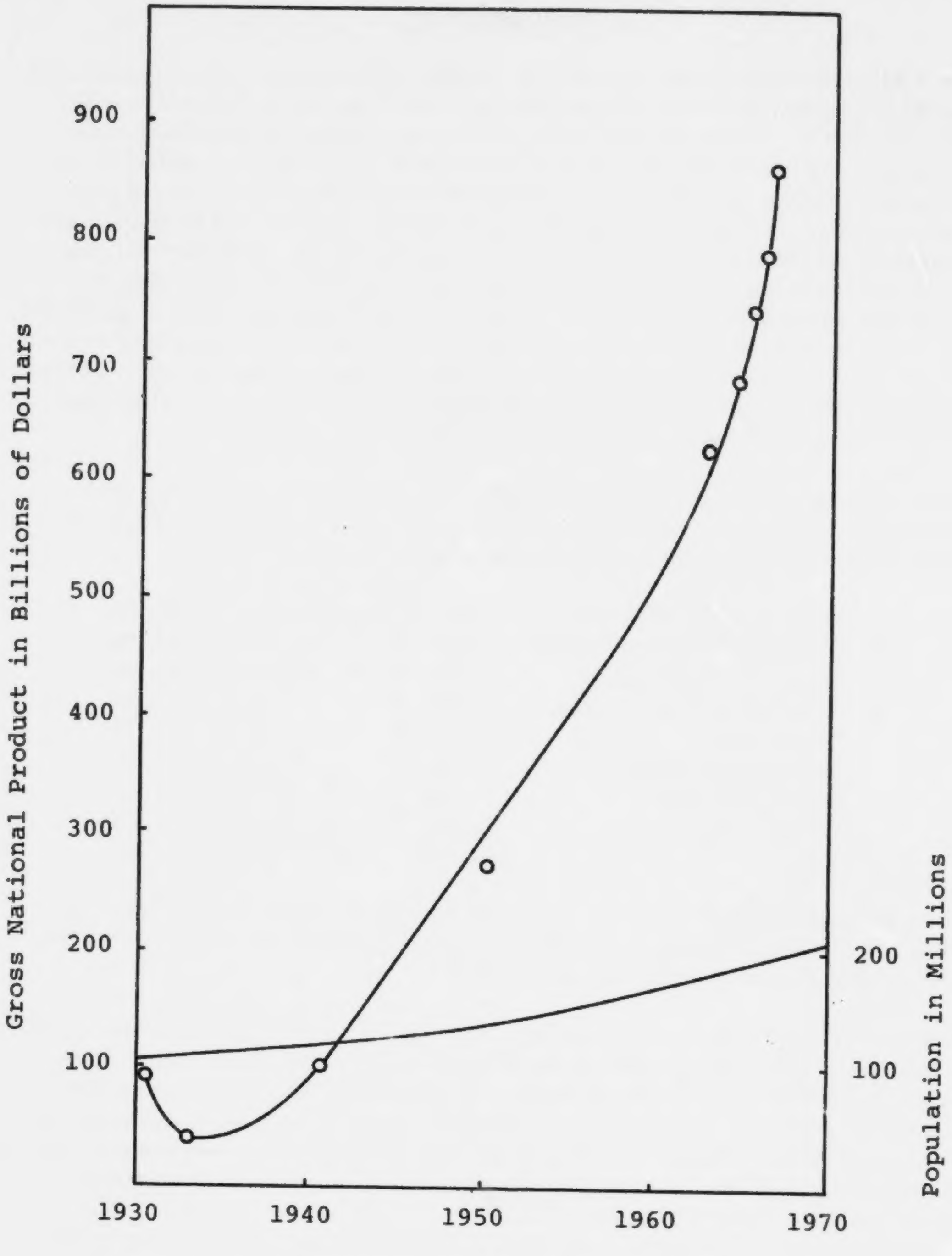


Figure 2. A Comparison of the GNP and Population
Growth in the United States 1930-70.
Federal Reserve Bulletin, 55, A68 (1969).

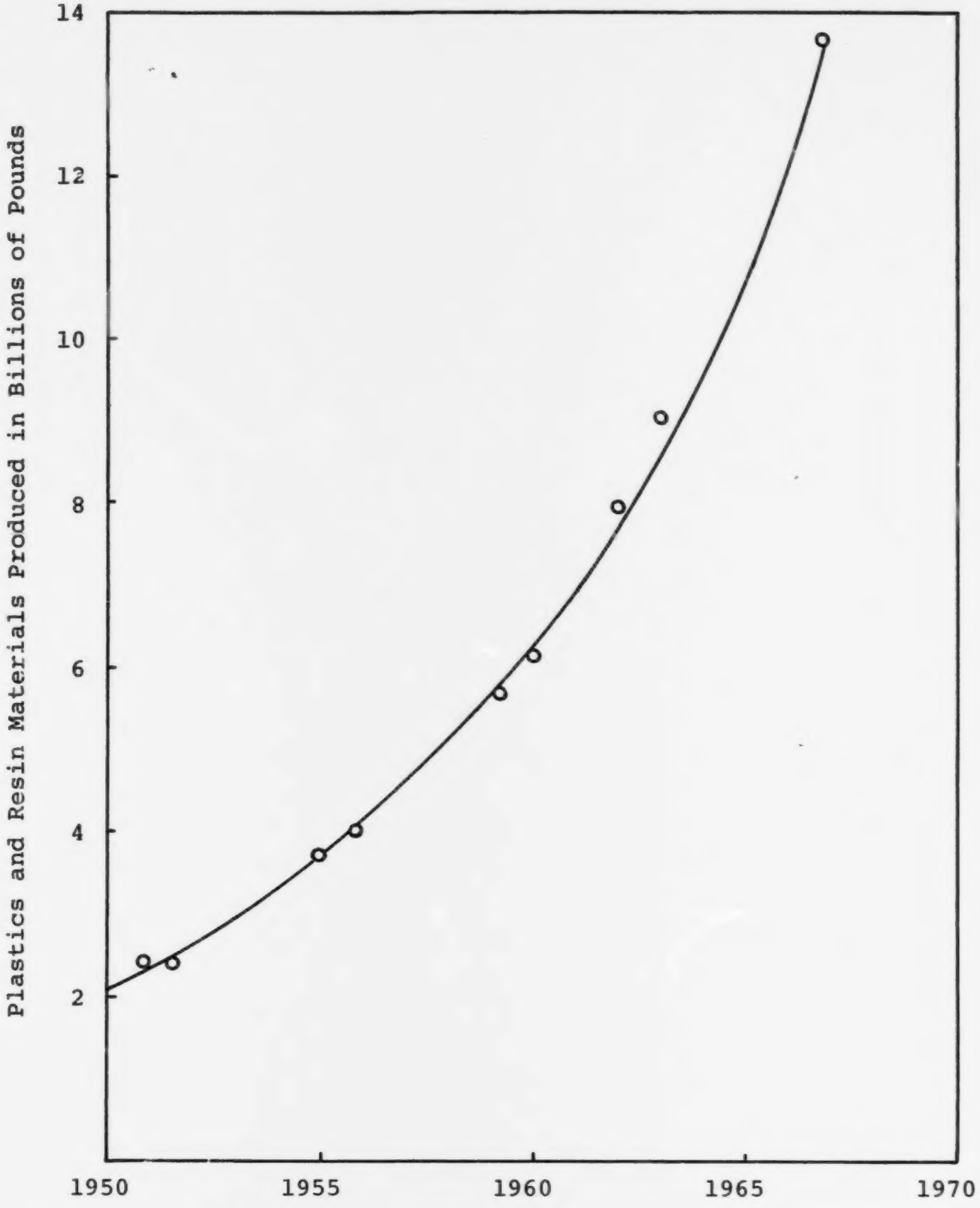


Figure 3. Production of Plastics and Resin Materials in the United States. United States Tariff Commission Reports on Synthetic Organic Chemicals. (1950-1967)

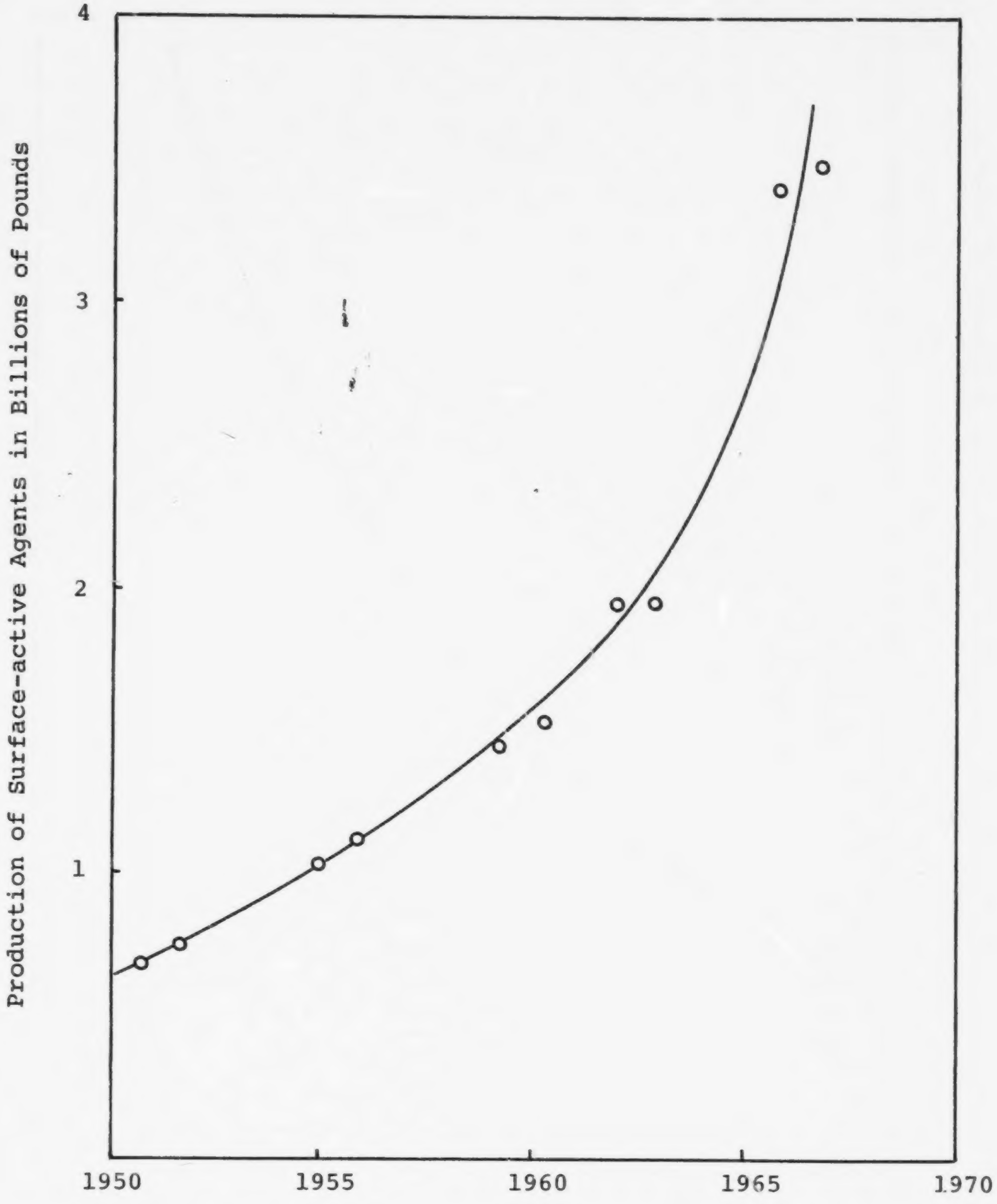


Figure 4. Surface-active Agents Produced in the United States. United States Tariff Commission Reports on Synthetic Organic Chemicals (1950-1967).

waste streams may very well produce a waste which is less suited for either biological or chemical treatment. This raises the question, Should industrial waste be treated by municipalities or by the plants themselves? No obvious answer exists, but any product or service that causes pollution should pay for its equitable share of restoring the water to a desirable condition.

A better insight into some of the questions that have been raised may be obtained if we look at changes that have occurred in the textile industry over the past twenty years and see how these changes will affect waste treatment methods.

Fibers

In 1950 the major fiber consumed on the American market was cotton. If man-made cellulosic fibers are not included, the quantity of man-made fibers produced at this time was hardly significant. This is illustrated by the curves shown in Figure 1.

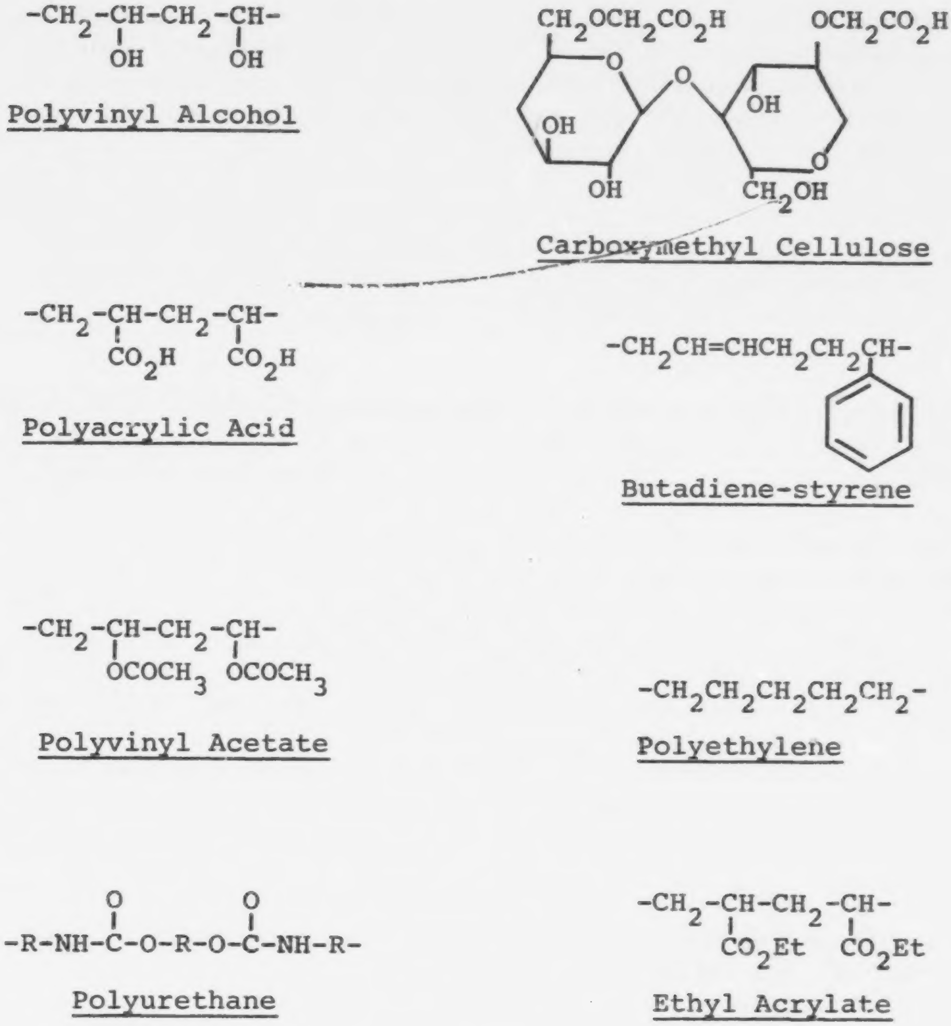
The lint from textile manufacturing and finishing is a noticeable part of the suspended solids in textile waste. In the case of natural fibers biological degradation will occur when the fiber is retained with the sludge in the treatment plant. This is not true for most synthetic fibers as they are comparatively inert. The buildup of synthetic fibers in a treatment plant using mechanical aeration can cause damage to pumps and aerators unless special precautions are taken to see that the fibers are removed from the waste stream before it enters the plant. This is generally done by screening the waste stream as it enters the treatment plant. In some cases this is a difficult operation because a screen system fine enough to remove fibers 15 microns in diameter may easily clog or remove suspended solids that are suitable for biological treatment.

The example just described shows in a visible way how an industrial waste stream has changed over the past 20 years.

Sizing

The principal slashing polymer used before 1960 was starch. This natural polymer of glucose is easily degraded biologically and should present no problem to the conventional waste treatment plant other than BOD loading.

The development of many synthetic fibers in the 1950's and their use in blended fabrics created the need for new sizes which were more compatible with the hydrophobic fibers. Some of those which were developed and are still in use are polyvinyl alcohol (PVA), carboxymethyl cellulose (CMC), and polyacrylic acid. The structures of these polymers are shown in Figure 5. Of these three materials polyvinyl alcohol and carboxymethyl cellulose are the most widely used. The total sizing materials entering waste streams today can be estimated from the fiber con-



Polyvinyl Alcohol

Carboxymethyl Cellulose

Polyacrylic Acid

Butadiene-styrene

Polyvinyl Acetate

Polyethylene

Polyurethane

Ethyl Acrylate

Figure 5. Structures of Some Commercial Polymers used by the Textile Industry.

sumption in Figure 1. If an average size concentration of 10% is assumed to be present on woven fabrics, which constitute 70% to 80% of the fabrics produced, approximately 400 million lbs. of size per year are currently entering textile finishing waste streams. This constitutes one of the major BOD loads on waste treatment plants in the case of starch (1).

Since PVA and CMC are resistant to biological degradation (2), we would not expect conventional treatment methods to alter their chemical structure. While the polymer may be partially removed from the waste water by adsorption on the sludge it is questionable whether this is an effective method of treatment. This brings up a point about the use of BOD analysis for industrial waste and suggests as others have (17) that organic carbons analysis would be more indicative of organic contaminants.

Scouring

The change in scouring which has possibly received the most attention since 1950 was the conversion to biodegradable detergents (18). Today most of the detergents are at least partially biodegradable so that foaming tendencies can be destroyed by microbial action. The increasing use of detergents is illustrated in Figure 4.

An important factor to consider today is the impact that solvents, which are used in scouring operations (19), will have on pollution. Several solvents such as mineral spirits, chlorobenzenes and perchloroethylene have been used to aid in the removal of oil born stains from synthetic fibers (20). Some of the solvents are inert to biological treatment (2) and may not be removed from a waste stream by the conventional waste treatment plant. More research is needed to develop effective methods of removing volatile chemicals from waste streams without contributing to the problem of air pollution.

A few of the major chemical manufacturers are now offering solvent processes to the textile industry for scouring where little water is used (21). In these cases nonflammable chlorinated solvents are used and the projected solvent recovery is between 90% and 97%. If a 93% recovery value is assumed and we apply it to a continuous finishing range running 70 yards a minute, we can visualize that nearly one ton of solvent per day per range will reach the atmosphere or waste stream. Chemical methods of treatment may be required. These could pay for part of their operation by recovering valuable solvent for reuse. When treatment methods are able to recover expensive chemicals from a waste stream, new production processes may be developed that would have been previously considered too expensive.

Mercerizing

The original purpose of mercerization was to improve the luster of cotton fibers.

Today the treatment of a cotton containing fabric with a caustic solution is as much for improving the dyeability and absorption characteristics of the fabric as anything else. Since man-made fibers are not mercerized, the use of the process will depend on the quantity of cotton fibers reaching the finishing plant.

A significant decrease in caustic consumption is obtained when caustic recovery units are installed in the finishing plant. Several studies (1, 22) have been made which document the improved efficiency of treatment plant operation when the caustic loading is decreased. The obvious advantages of this process accounts for its use by most finishing plants.

If the fiber consumption shown in Figure 1 continues to change at its present rate, the percentage of fabrics receiving caustic treatments will decrease considerably in the next ten years.

Bleaching

This is one textile finishing operation which has shown an improvement over the past twenty years as far as water pollution is concerned. In 1950 the major bleaching agent used was sodium hypochlorite (23); today it is hydrogen peroxide. Hydrogen peroxide decomposes to water and oxygen and leaves no dissolved solids or objectionable residues behind. In fact it can raise the waste stream's dissolved oxygen concentration which is desirable in many cases.

Solvent systems for bleaching are being examined by academic institutions (24) and chemical manufacturers (21). To be economical these processes will require efficient solvent recovery operations. With the use of suitable solvents a combined scouring and bleaching operation could be developed that would use very little water. A change in wastewater volume such as this could drastically affect the operation of a conventional biological treatment plant. Waste treatment plants must be designed with built-in flexibility where process changes are anticipated.

Dyeing

This is a second only to chemical finishing in the changes that occur each year. Not only have approximately forty new fibers appeared on the market in the past twenty years, but new dyes for these fibers are developed each year. The "Textile Chemist and Colorist" (25) lists twenty-six new dyes for 1969 alone, and this is by no means a complete listing. The market demands better performance each year. Dyes have to be more resistant to ozone, nitric oxides, light, hydrolysis and other degradative environments to capture a valuable portion of the commerical market. It is not surprising that studies on the biological degradation of dyestuffs yield negative results when the dyes themselves are designed to resist this type of treatment. The high color value or absorptivity needed for a commercial dye is not an advantage when that dye ends up in a waste stream. Although some dyes are biologically degradable (26), most that are present in waste water are objectionable for their coloration. To effectively remove dyes from textile waste effluents, non-biological processes will have to be used in many instances. Dyes are just too refractory to undergo degradation in the time required for conventional waste treatment. Initial studies using chemical treatment methods (8) look good, but more research is needed to establish clearly the parameters for chemical treatment.

The auxiliary chemicals used in aqueous dyeing can also present a problem to biological processes. Carriers such as methyl naphthalene, chlorobenzenes, biphenyl, orthophenyl phenol, and benzyl alcohol are used to speed up the dyeing process. When the dyeing operation is completed, these chemicals are discharged to the sewer. Some are biodegradable; others are not. Even though the nonbiodegradable chemicals may be absorbed by the sludge in an activated sludge process, the problem is not alleviated if the sludge is not handled properly for ultimate disposal to prevent further contamination.

Finishing

A treatment of a fabric that modifies its physical or chemical properties may be classified as finishing. Today there are finishes that are commonplace which were either nonexistent or not in significant use twenty years ago. Examples are permanent press finishes, oil repellents, soil release agents, low crock polymers, abrasion resistant polymers, fire retardants, lamination polymers, germicide and fungicide chemicals, to mention a few. The curve in Figure 3 illustrates the increase in production of these polymers and resins which are used by the textile industry. A small number of these materials are biodegradable; most are not.

The polymers used for textile finishing are generally supplied to the finishing plant as emulsions. This is done because of the ease of handling and cost of manufacturing. Most polymer emulsions are sensitive to pH, salt or agitation and may coagulate when they enter waste streams. The sewer lines may then become clogged with inert materials which have to be removed by hand. Although the bulk of the polymer emulsion can be coagulated and removed in a treatment plant, some of it remains emulsified and is not removed by biological treatment. For complete removal of the polymer emulsion, chemical treatment is sometimes necessary. However, this is an additional step which in itself could replace much of the need for biological treatment. Several polymers which are used commercially are shown in Figure 5.

Most of the finishes used for wash and wear and permanent press fabrics are manufactured from urea, formaldehyde, melamine and glyoxal compounds. Some of these products are readily degradable by microbial action; others are not (2). The formaldehyde derivatives can react with themselves or other chemicals in the waste stream to form insoluble products that may be removed by sedimentation.

A class of finishing chemical that has come into prominence is recent years is fire retardants. These chemicals have received attention because of the growing concern over the flammability of textile fabrics. Most of the commerical fire retardant finishes are phosphorous and nitrogen containing compounds (27). Two examples are triaziridyl phosphine oxide (APO) and tetrakis (hydroxymethyl) phosphonium chloride (THPC). APO, a chemisterolant (28), could present a serious problem if it got into a natural stream. The chemical reactivity of APO would facilitate its hydrolysis in a waste stream and prevent the parent compound from reaching the discharge water of a treatment plant. Whether or not these initial hydrolysis products are toxic or harmful is not known. This points to the increasing need for the characterization of industrial waste.

The newest finishes to appear on the market are soil release materials (29). These chemicals are applied to fabrics to aid in the removal of dirt and oil born stains. Some are acrylate and methacrylate copolymers containing free carboxyl groups. Most are resistant to biological treatment. Either physical or chemical methods may be required for their effective removal from wastewater.

The many changes discussed above show that considerable discretion must be used in designing a waste treatment plant for the textile industry.

THE CHARACTERIZATION OF TEXTILE EFFLUENTS

A number of mechanical operations have to be performed to convert textile fibers into fabrics. The fibers must be combined into yarns and then the yarns into fabrics. After the fabrics are manufactured, they are subjected to several wet processes collectively known as finishing, and it is in these finishing operations that the major waste effluents are produced. To get more insight into the characteristics of the waste from these finishing operations we will discuss each one in some detail.

Cotton

The consumption of cotton fibers by textile mills in the United States exceeds that of any other single fiber; however, the total synthetic fiber poundage consumed by the textile industry is greater than that of cotton as seen in Figure 1.

The operations required to produce a piece of finished cotton fabric are shown in the flow diagram of Figure 6; in any given mill, either the weaving or knitting route will be utilized, not both. For a more detailed explanation of cotton processing, refer to the American Cotton Handbook (30).

Slashing is the first process in which liquid treatment is involved. In this process, the warp yarns are coated with "sizing" in order to give them tensile strength to withstand the pressures exerted on them during the weaving operation.

Such substances as starch, starch substitutes, polyvinyl alcohol, carboxy methyl cellulose, gelatin glue and gums have been used as size agents. The source of pollution in this process results from the cleaning of slasher boxes, rolls, and make up kettles. The volume is therefore usually low; however, the BOD can be quite high, especially if starch is used (2).

The operation of desizing removes the substance applied to the yarns in the slashing operation, by hydrolyzing the size into a soluble form. There are two methods of desizing - acid desizing and enzyme desizing.

In acid desizing, the fabric is soaked in a solution of sulphuric acid, at room temperature, for 4 to 12 hours (31), and then washed out. In enzyme desizing, couplex organic compounds produced from natural products or malt extracts are used to solubilize the size. The bath is maintained at a temperature of 130° - 180° F. and a pH of 6-7.7, for a period of 4-8 hours. Due to the unstable nature of these organic compounds, the whole bath must be discarded after each batch. After the size has been solubilized, the fabric is rinsed clean. Desizing contributes the largest BOD of all cotton finishing processes - about 45 percent (32).

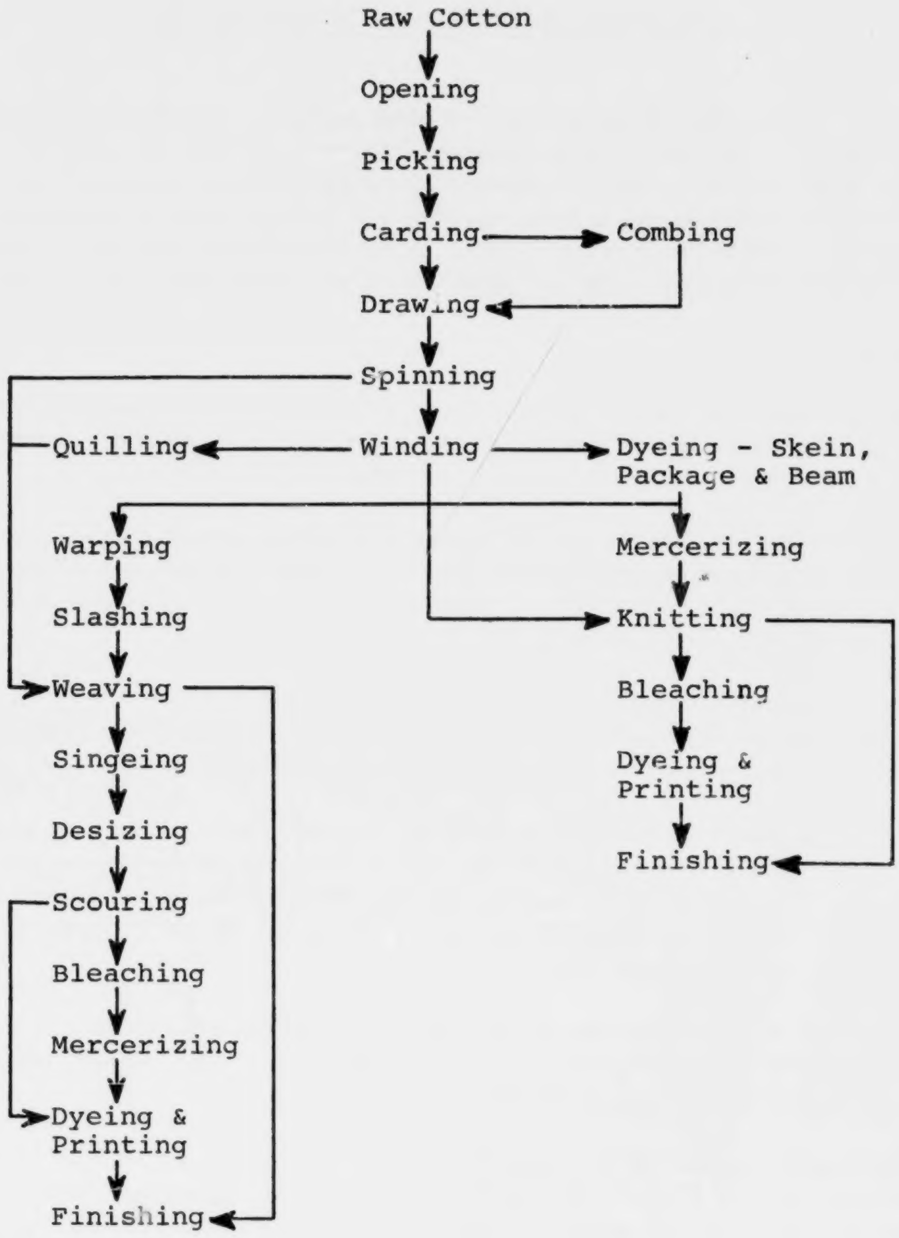

Raw Cotton
Opening
Picking
Carding
Combing
Drawing
Spinning
Quilling
Winding
Dyeing - Skein, Package & Beam
Warping
Mercerizing
Slashing
Knitting
Weaving
Bleaching
Singeing
Dyeing & Printing
Desizing
Finishing
Scouring
Bleaching
Mercerizing
Dyeing & Printing
Finishing

Figure 6. Process Flow Sheet for Cotton Goods

Scouring follows desizing. In this process, the cotton wax and other non-cellulosic components of the cotton are removed by hot alkaline detergents or soap solutions. In most modern plants, scouring is done in conjunction with desizing rather than as separate operation. Caustic soda and soda ash along with soaps and synthetic detergents and inorganic reagents are used to remove the non-cellulosic impurities. The bath is characterized by a pH of 10 to 13 and temperatures of 250° F. (31). Although the strength of alkali in the beginning of the operation is between 1 percent and 5 percent, the waste liquor will have a 0.3 percent alkaline concentration, the rest being taken out of solution by the cotton fibers. As in the desizing operation, the scouring process is a batch operation requiring the fabric to remain in the kier for a period of from 2 - 12 hours. Scouring is the second largest BOD contributing process in the finishing of cotton textiles - about 31 percent (32). Following the "boil-off", the goods are rinsed with hot and cold water to remove residual alkali.

Bleaching, the next process, removes the natural yellowish coloring of the cotton fiber and renders it white. The three bleaches most commonly used for cotton are sodium hypochlorite, hydrogen peroxide, and sodium chlorite. In hypochlorite bleaching, the fabric is rinsed, saturated with a weak solution of sulfuric or hydrochloric acid, rinsed again, and then passed through the hypochlorite for a period of up to 24 hours (31). The process is done at room temperature with a pH range of 9 to 11. When bleaching with sodium chlorite, acetic acid is used in place of sulfuric or hydrochloric acid, the temperature of the bath is hot (180° - 185° F.), and the pH is 3.5-5.5. Hydrogen peroxide is used for continuous bleaching. This process calls for a washer, with a 140° - 175° F. temperature, saturation with caustic soda at 175° - 180° F., passage through the peroxide at 195° F., and a final rinse. The pH range used in hydrogen peroxide bleaching is 9 to 10 (31). The final rinse may contain an antichlor, sodium bisulfite or sulfuric acid, to remove residual chlorin from the fabric. The bleaching process contributes the lowest BOD for cotton finishing (32).

The mercerization process was originally developed to give increased luster to cotton fabrics. Today it is still used for that purpose, but more importantly to impart increased dye affinity and tensile strength to the fabric. It is estimated that only 30 percent of all cotton fabrics are now mercerized, and with the increasing use of cotton-polyester blends, less will probably be done in the future (33). The process uses a 15 to 30 percent solution of sodium hydroxide at room temperature for 1/2 to 3 minutes (34). The fabric is then rinsed in an acid wash to neutralize the fabric and washed in water and then dried. The effluent from this process is alkaline and high in dissolved solids, but low in BOD (33).

After mercerizing, the goods are sent to the dye house or color shop. In the dye house they are dyed either in small volumes on batch process machines, or on continuous dyeing ranges in large volumes. There are five important classes of dyes used on cotton fabrics: vat, developed, naphthol, sulphur, direct, and aniline black.

The dyeing process is carried out in an aqueous bath with pH variations of 6 to 12, and temperature variations from room temperature to boiling (35). Table I lists the various chemicals present in the baths used in cotton dyeing.

TABLE I

CHEMICALS PRESENT IN COTTON DYEBATHS

Dye Type	
Aniline Black	Aniline hydrochloride, sodium ferrocyanide, sodium chlorite, pigment, soap.
Developed	Dye, penetrant, sodium cloride, sodium nitrate, hydrochloric acid or sulfuric acid, developer (beta naphthol), soap or sulfated soap or fatty alcohol.
Direct	Dye, sodium carbonate, sodium chloride, and wetting agent or soluble oil or sodium sulfate.
Naphthol	Dye, caustic soda, soluble oil, alcohol, soap, soda ash, sodium chloride, base, sodium nitrate, sodium nitrite, sodium acetate.
Sulfur	Dye, sodium sulfide, sodium carbonate, sodium chloride.
Vat	Dye, caustic soda, sodium hydrosulfite, soluable oil, gelatine, perborate or hydrogen peroxide.

Source: (Ref. 36, p. 482)

In the color shop, the goods are printed with colored designs or patterns. The usual method is by roller machines (32). The color is imparted to the fabric from the rolls which contain the printing paste. This paste contains dye, thickener, hygroscopic substances, dyeing assistants, water, and other chemicals. The pollutional load from the color shop comes mainly from the wash-down rinses used to clean the equipment in the shop and the cloth rinsings. The pollutional load is rather low in both volume and BOD (32). When a mill does both printing and dyeing, the BOD contribution of the combined processes is 17 percent, and the total BOD load comes from the process chemicals used (32).

Table II. Pollution Effect of Cotton Processing Wastes

Process	Wastes (p.p.m.)			Gallons Waste per 1,000 lbs. goods	Pounds B.O.D. per 1,000 lbs. goods	Pounds Total Solids per 1,000 lbs. goods
	pH	B.O.D.	Total Solids			
Slashing, sizing yarn*	7.0-9.5	620-2,500	8,500-22,600	60-940	0.5-5.0	47-67
Desizing	-------	1,700-5,200	16,000-32,000	300-1,100	14.8-16.1	66-70
Kiering	10-13	680-2,900	7,600-17,400	310-1,700	1.5-17.5	19-47
Scouring	-------	50-110	-------------	2,300-5,100	1.36-3.02	-------
Bleaching (range)	8.5-9.6	90-1,700	2,300-14,400	300-14,900	5.0-14.8	38-290
Mercerizing	5.5-9.5	45-65	600-1,900	27,900-36,950	10.5-13.5	185-450
Dyeing:						
Aniline Black	-------	40-55	600-1,200	15,000-23,000	5-10	100-200
Basic	6.0-7.5	100-200	500-800	18,000-36,000	15-50	150-250
Developed Colors	5-10	75-200	2,900-8,200	8,900-25,000	15-20	325-650
Direct	6.5-7.6	220-600	2,200-14,000	1,700-6,400	1.3-11.7	25-250
Naphthol	5-10	15-675	4,500-10,700	2,300-16,800	2-5	200-650
Sulfur	8-10	11-1,800	4,200-14,100	2,900-25,600	2-250	300-1,200
Vats	5-10	125-1,500	1,700-7,400	1,000-20,000	12-30	150-250

*Cloth Weaving Mill Waste. (Composite of all waste connected with each process.)
Reference 37, p8

Table II lists the range of pollutional loads of the various cotton textile wet-processing operations. The ranges have been compiled from the values given by several authors in different studies. Wide variance in the values of each process is caused by the following: the problems of representative sampling in a highly variable waste stream; the several methods of technology available, for example, batch vs. continuous processing; the interchangeability of process chemicals, for example, hypochlorite vs. peroxide in bleaching; and the wide variety of cotton fabrics manufactured. Any particular cotton processing mill should be producing effluents with values falling within the ranges listed in Table II.

Each process produces a waste with different characteristics. Table III characterizes the wastes from cotton wet processing.

TABLE III

CHARACTERISTICS OF COTTON PROCESSING WET WASTES

Process	Significant Pollutants
Desizing	High BOD, neutral pH, high total solids
Scouring	High BOD, high alkalinity, high total solids, high temperature
Bleaching	High BOD, alkaline pH, high solids
Mercerizing	Low BOD, alkaline pH, low solids
Dyeing and Printing	High BOD, high solids, neutral to alkaline pH

Source: (Ref. 33, p. 83)

In treating 1000 pounds of cotton fabric, a composite waste stream has the following characteristics: pH of 8 to 11; the color either a gray or that of the predominant dye used; the BOD, total solids and suspended solids with concentrations of 200 to 600 p.p.m., 1,000 to 1,600 p.p.m. and 30 to 50 p.p.m., respectively. These wastes will be contained in a volume of 30,000 to 93,000 gallons (37).

Based on estimates of product mix; that is, the amount of 100 percent cotton fabrics and cotton-synthetic blends; and the degree of technology mix; that is, the number of modern plants and out-of-date plants; and the projected growth rate of the cotton finishing industry for the next twelve years, the Federal Water Pollution Control Administration has predicted a gross wasteload and wastewater volume for selected years in this period. Table IV lists these estimates for BOD, suspended solids, total dissolved solids and volume of wastewater for 1970, 1971, 1972, 1977 and 1982.

TABLE IV

PROJECTED GROSS WASTELOAD AND WASTEWATER VOLUME FOR COTTON FINISHING WASTES FOR SELECTED YEARS, 1970-1982

Year	BOD	Suspended Solids	Total Dissolved Solids	Volume (Billion Gallons)
		(Million Pounds)		
1970	529	165	497	99
1971	528	164	496	100.1
1972	526	163	495	100.1
1977	516	160	494	102.3
1982	502	154	483	105.6

Source: (Ref. 33, p. 62)

The reason for the gradual decrease of the gross pollutional load in the coming years is based on these assumptions: new machinery, which tends to produce less pollution per unit of cloth, due to water reuse and counter current flow designs, will continue to be purchased; trends in process modification, new chemical manufacture and better housekeeping will continue and a larger percentage of the wastes will be treated due to increased efficiency of treatment facilities and increased pressure by State, local, and Federal agencies (33).

Wool

Wool fiber consumption is the smallest of the three groups, and the trend seems to be toward less demand in the future on a percentage basis (39). Wool fibers are processed into two fabric types: woolen fabrics and worsted fabrics - the latter being used for expensive garments. Figure 7 outlines the operations that take place in woolen and worsted fabric manufacturing. The American Wool Handbook

(40) gives a detailed account of each of these fiber and fabric manufacturing operations. Figure 8 is a process flow chart of wool and worsted fabric finishing operations. As in cotton textile production, either knitting or weaving will be done at a particular mill, not both.

Scouring is the first wet process that wool fibers receive. This process removes all the natural and acquired impurities from the woolen fibers.

There are two methods of wool scouring - detergent scouring and solvent scouring. In the United States, the detergent scouring process is used almost exclusively (40). There are two types of detergent scouring - the soap-alkali process and the neutral detergent scouring process. In the soap-alkali process, a soap or synthetic detergent and a mild alkali such as sodium carbonate or soda ash is added to a bath at a pH of 9.5 to 10.5 and heated to temperatures of 130° F. This process consumes a volume of 8,000 to 12,000 gallons (40) of water per 1000 pounds of wool fiber. In the neutral detergent process, non-ionic detergents of the ethylene oxide condensate class are added to water at a pH of 6.5 to 7.5 and a temperature of 135° to 160° F. (40).

The process is carried out in a series of four open bowls called "scouring train". The first two bowls contain the detergent or soap and alkali and perform the scour. The last two bowls serve to rinse the fibers clean. For every pound of scoured woolen fiber one and one-half pounds of waste impurities are produced (32); therefore, wool scouring produces one of the strongest industrial wastes in terms of BOD (33). This process contributes 55 to 75 percent of the total BOD load in wool finishing.

Depending on whether the fabric is classified as woolen or worsted, the remaining wet processes will vary. The burrpicking and carbonizing step is done to remove any vegetable matter remaining in the wool after scouring. If the wool is to be stock dyed, it is done prior to dyeing; if the wool is to be piece dyed, the fabric is carbonized prior to dyeing.

Due to the popularity of multi-colored fabrics, stock dyeing is used more often today than is piece good dyeing (33). The two classes of dyes used on wool fiber are acid dyes and metalized dyes. Table V lists the chemicals found in the woolen fiber dyebaths.

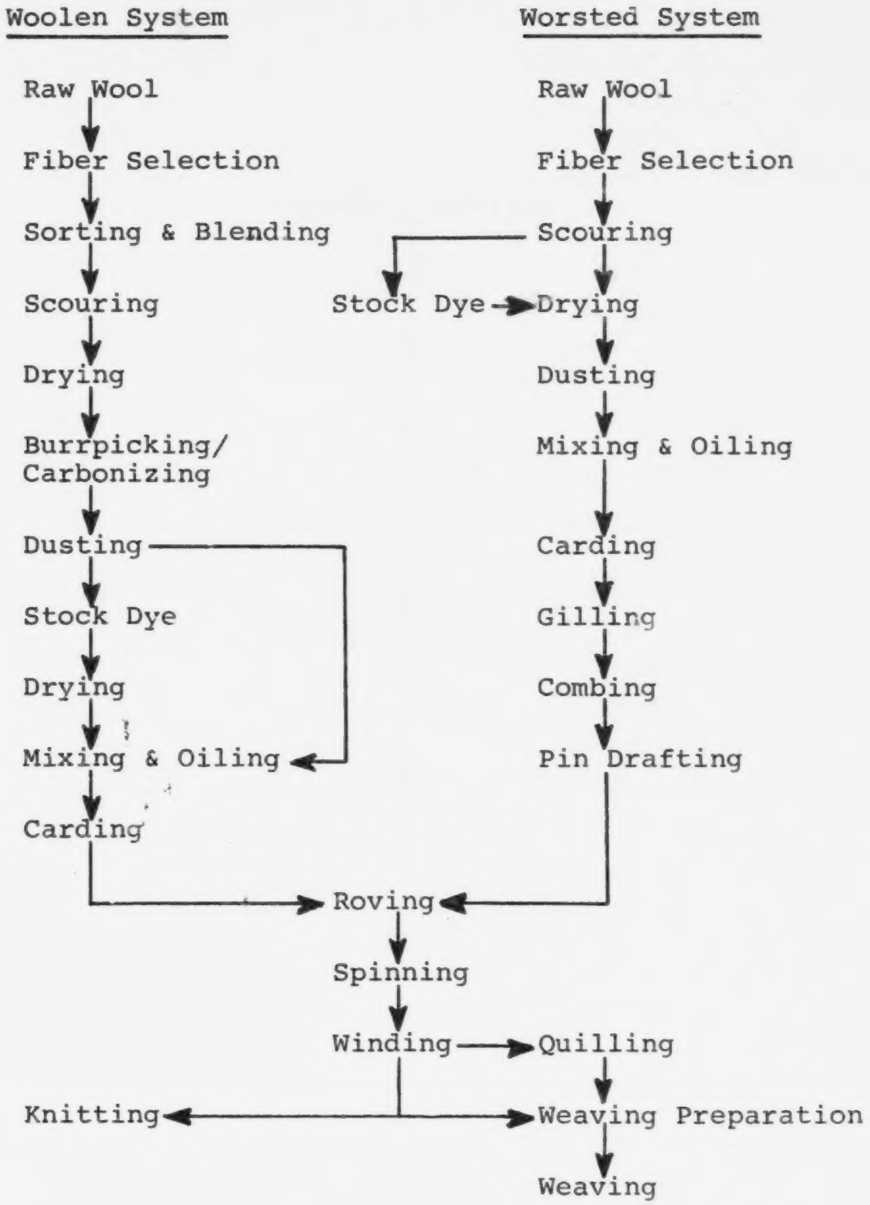

Woolen System
Worsted System
Raw Wool
Fiber Selection
Sorting & Blending
Scouring
Drying
Burrpicking/
Carbonizing
Dusting
Stock Dye
Drying
Mixing & Oiling
Carding
Raw Wool
Fiber Selection
Scouring
Stock Dye
Drying
Dusting
Mixing & Oiling
Carding
Gilling
Combing
Pin Drafting
Roving
Spinning
Winding
Quilling
Knitting
Weaving Preparation
Weaving

Figure 7. Wool and Worsted Fabric Manufacturing.

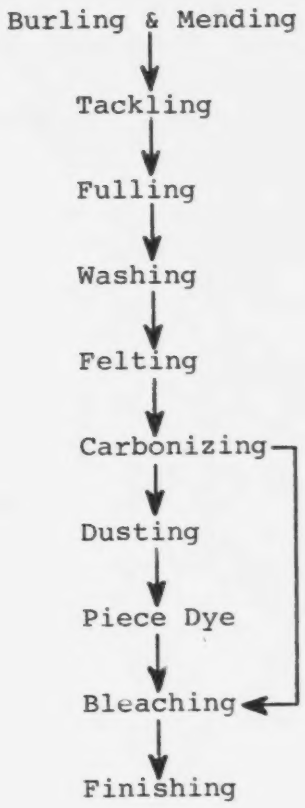

Burling & Mending
Tackling
Fulling
Washing
Felting
Carbonizing
Dusting
Piece Dye
Bleaching
Finishing

Figure 8. Wool and Worsted Finishing Operations

TABLE V

CHEMICALS PRESENT IN WOOL DYEBATHS

Dye Type	Chemicals Present
Acid Dyes	Dye, sulfuric or acetic acid or ammonium sulfate and Glauber Salt
Metalized Dyes	Dye, acetic or sulfuric acid or ammonium sulfate

Source: (Ref. 41, p. 332).

In the dyeing of wool fibers it is impossible to fix definite formulas. The dye, grade of wool, and the type of dyeing machine will alter the formulation (42). In the acid dyeing baths the temperature of the solution will vary from 140° to 212° F. In the metalized dyeing the average final temperature is 185° F. The pH varies depending on the amount of residual alkali left in the wool fibers after the scouring process (31). The volume of waste water generated by dyeing, either stock or piece goods is large and highly colored. Many of the chemicals used for wool dyeing are toxic (33). The BOD load is contributed by the process chemicals used, and the contribution of wool dyeing to the mill's total BOD load is 1 to 5 percent (32).

Although the mixing and oiling step does not contribute directly to the water waste volume, the oil finds its way into the waste stream through the washing after fulling operation. The percentage contribution to total BOD load of this process varies with the type of oil used. The traditional oiling agent is olive oil, which produces a high BOD that could contribute 10 percent of the total BOD load (32); however, there is a trend toward the use of non-ionic emulsifiers in oiling, that greatly reduces the BOD contribution in this area (40).

Fulling is another operation that does not directly contribute to the waste stream, until the process chemicals are washed out of the fabric in the wash after fulling operation (32). There are two common methods of fulling, alkali fulling and acid fulling. In the former case, soap or synthetic detergent, soda ash, and sequestering agents are used in the fulling solution. In acid fulling, the fabric is impregnated with an aqueous solution of sulfuric acid, hydrogen peroxide, and minor amounts of metallic catalysts (chromium, copper and cobalt). In either case, the water is heated to a temperature of 90° to 100° F. (32). Acid fulling is always followed by alkali fulling.

Following the fulling operation, the goods are washed to remove the fulling chemicals mentioned above and the carding oil described in the mixing and oiling discussion. It is estimated that from 10 to 25 percent of the fulled cloth's weight is composed of process chemicals that will be washed out in this process and wasted (32). Due to this large amount of waste, wool washing after fulling is the second largest source of BOD, contributing from 20 to 35 percent of the total (33). The usual procedure in this process is to subject the fulled cloth to two soapings, two warm rinses, and one cold rinse. In the first soaping, nothing is added to the water, the soaping action takes place when agitation of the fabric causes the soap or synthetic detergent to produce suds, thus washing the fabric. In the second soaping, a 2 percent solution of soap or synthetic detergent is used. The warm water rinsings are done at 100° to 110° F., while the cold rinse is done below 100° F. (32). This process consumes from 40,000 to 100,000 gallons of water for each 1000 pounds of wool fabric (33). Analyses show that wool, once thoroughly washed, will produce little or no BOD of itself on being rewashed (32).

After the dusting process, which follows carbonizing the fabric or stock of fibers, the acids used in carbonizing must be removed. In order to accomplish this, the wool is rinsed to remove the bulk of the acid. Following the rinse, the wool is neutralized by a low concentration solution of sodium carbonate. After this neutralization bath the fabric is rinsed again. Since sulfuric acid and soda ash have little or no BOD, this process contributes less than 1 percent of the total BOD load (33).

Wool is bleached if white fabric or very light shades of colored cloth are required; however, the amount of wool fabric bleached is rather small (33). There are three methods of bleaching wool - with sulphur dioxide, with hydrogen peroxide, and with the optical brighteners. With hydrogen peroxide and sulfur dioxide bleaching the BOD contribution is usually less than one-half of a percent; optical brighteners, which use organic compounds, contribute about 1 percent of the total BOD (33).

In the processing of woolen fibers, five sources of pollutional load exist - scouring, dyeing, washing after fulling, neutralizing after carbonizing, and bleaching with optical brighteners. Table VI contains average values of the pollution load of each of these processes, and Table VII lists the significant pollutants from each process.

Table VI. Pollutional Loads of Wool Wet Processes.

Process	pH	B.O.D. p.p.m.	B.O.D. lbs/1,000 lbs. cloth	Total Solids p.p.m.	Volume (gallons)
Scouring	9.0-10.4	30,000-40,000	104.5-221.4	1,129-64,448	5,500-12,000
Dyeing	4.8-8.0	380-2,200	9.0-34.3	3,855-8,315	1,900-2,680
Washing	7.3-10.3	4,000-11,455	31-94	4,830-19,267	40,000-100,000
Neutralization	1.9-9.0	28	1.7-2.1	1,241-4,830	12,500-15,700
Bleaching	6.0	390	1.4	908	300-2,680

Source: Ref. 32, p. 60; Ref. 33, p. 20; Ref. 43, p. 386; Ref. 44, p. 37.

TABLE VII

CHARACTERISTICS OF WOOL PROCESSING WASTES

Process	Significant Pollutants
Scouring	High BOD, high grease content, high alkalinity, turbid brown color and a temperature of 115° to 125° F.
Dyeing	Acid pH, highly colored, relatively high in BOD and possibly toxic
Washing	High BOD, high oil content and temperatures of 110° to 150° F.

Source: (Ref. 33, p. 13).

In Table VI, the pollutional load values vary greatly due to different methods of accomplishing the same process; for example, dyeing can use either acetic acid or ammonium sulfate as a dye assistant, the latter having a lower BOD loading. Variance in volume is caused by differences between batch and continuous processes. In the pH values, the large variance in neutralization is due to the fact that the first soapings' function is to remove residual acid from the fabric; whereas, the second soaping adds alkali to the bath. For scouring, washing and neutralizing, the values are for the entire process, not separate bowls.

In treating 1000 pounds of scoured wool, the total wasteload will contain 1000 pounds of grease, suet, and dirt, plus up to 500 pounds of process chemicals (detergents, alkali, softeners, etc.) (32). This wasteload is broken down into 250 pounds of BOD, 188 pounds of alkalinity, and 40.5 pounds of acidity (45). The volume of water used will range from 55,725 to 133,060 gallons (32,45). A composite waste stream produced by the finishing of wool fibers would have the following pollutional loadings: pH-9.0 to 10.5; BOD and total solids concentrations of 432 to 1200 p.p.m. and 6,470 p.p.m. respectively (44,45,46). The effluent will have a brown colloidal color, tinged with the most used dye color (32).

As in cotton finishing, the Federal Water Pollution Control Administration has estimated the gross wasteload, in pounds of BOD, and the wastewater volume for the selected years in the period 1970-1982. These estimates are based on the following factors: (33)

1. anticipated growth rate of the wool finishing industry
2. the assumptions that the industry will continue to purchase processing machinery and process chemicals that tend to produce a lower pollutional load per unit of fabric processed
3. treatment facilities will achieve more efficient pollution load removal
4. increased pressure by Federal, State and local regulatory agencies concerning pollution

The Administration's estimates are contained in Table VIII.

TABLE VIII

PROJECTED GROSS WASTELOAD AND WASTEWATER VOLUME FOR WOOLEN FINISHING WASTES FOR SELECTED YEARS, 1970-1982

Year	BOD (Million lbs.)	Volume (Billion Gals.)
1970	133.0	28.35
1971	133.2	28.40
1972	133.2	28.40
1977	134.2	28.6
1982	136.0	29.0

Source: (Ref. 33, p. 22).

Unlike cotton, the total waste discharges of wool are expected to increase slightly in the twelve year period. Although no reason is given for this increase, a reasonable conclusion would be that it is impossible to foresee any major process changes in wool finishing.

Synthetics

In this category of textile fibers there are two broad classifications: cellulosic and non-cellulosic fibers. The two major cellulosic fibers are rayon and cellulose acetate. The major non-cellulosic fibers are nylon, polyester, acrylics and modacrylics. There are other fibers in both classes, but at present they are not consumed in as large a volume as the six fibers mentioned above. The largest volume of synthetic fibers consumed by textile mills comes from the non-cellulosic fibers (39); and the trend is toward an even greater demand in the future, particularly for polyester fibers (47). Synthetic fibers can be converted into fabrics in one of two ways. Continuous filament yarns can be used to manufacture 100 percent synthetic fabrics, or staple yarns can be used to produce fabrics that are blends of man-made fibers or man-made and natural fibers. In Figure 9 a process flow chart shows the operations required to produce a 100 percent synthetic fabric; Figure 10 shows the processes required for the production of blended fabrics. Blended fabrics are processed according to the natural fiber component of the yarn (32). As in cotton and wool processing, the yarns are either woven or knitted, not both.

For a more detailed description of synthetic fiber manufacture, processing, and blending, refer to Man-Made Fibers (48), Man-Made Fibers-Science and Technology (49), and the Man-Made Fiber Fact Book (50).

The first process in which synthetic fibers are subjected to an aqueous treatment is stock dyeing, unless the fabric is to be piece dyed. When stock dyeing is used, the liquid waste discharge will vary from about 8 to 15 times the weight of the fibers dyed (51). A more detailed explanation of synthetic fiber dyeing will be given in the discussion on individual fibers.

Due to the low moisture regain of the synthetics, static electricity is a problem during processing. To minimize this problem, anti-static oils are applied to the yarns, which also serve as lubricants and sizing compounds. Those compounds commonly used are: polyvinyl alcohol, styrene-base resins, polyalkylen glycols, gelatin, polyacrylic acid, and polyvinyl acetate (52). These compounds become a source of water pollution when they are removed from the fabrics during scouring (32).

Since the manufacture of synthetic fibers can be well controlled, chemical impurities are relatively absent in these fibers; therefore, only light scouring and little or no bleaching are required prior to dyeing; and if synthetics are bleached, the process is not normally a source of organic or suspended solids pollution; however, the process will generate dissolved solids if chlorine bleaches are used (33).

Each of the synthetic fibers is processed in varying sequences of operations; therefore, each major synthetic fiber must be examined individually.

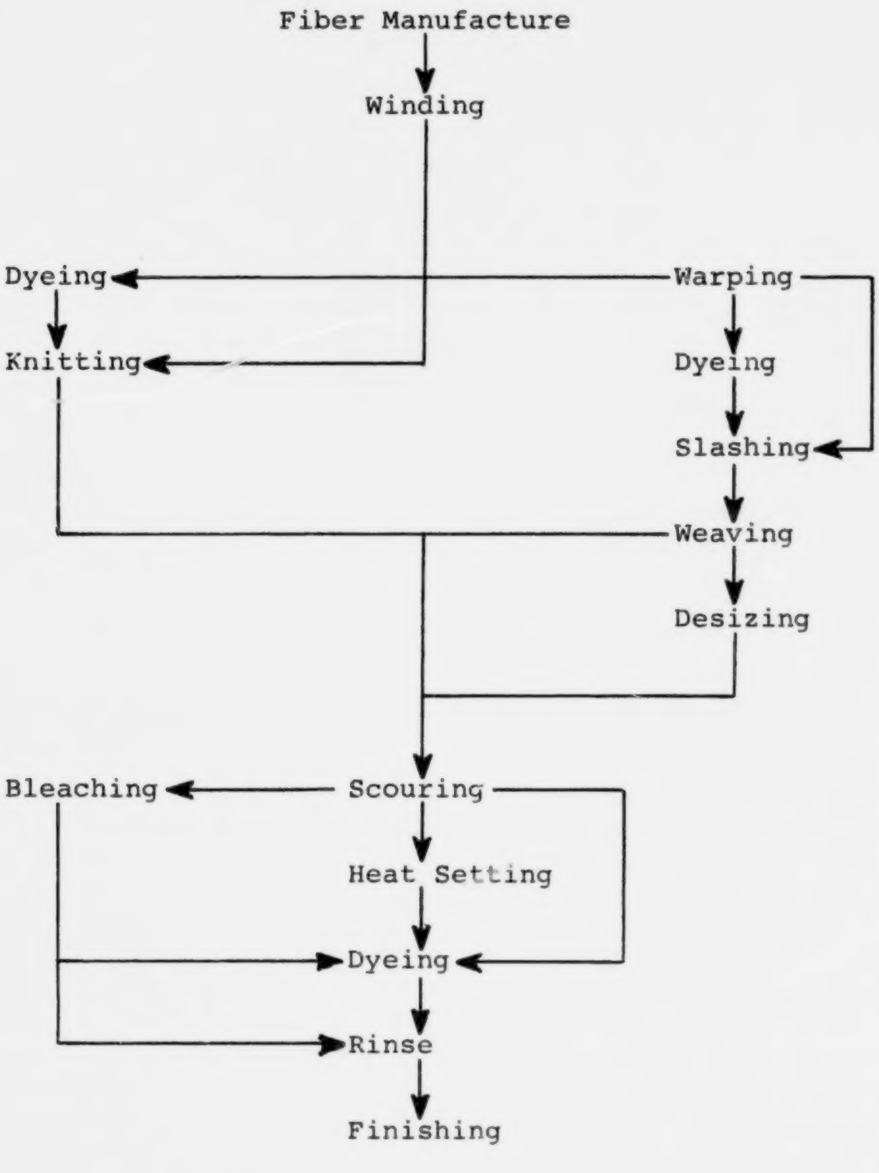

Fiber Manufacture
Winding
Dyeing
Warping
Knitting
Dyeing
Slashing
Weaving
Desizing
Bleaching
Scouring
Heat Setting
Dyeing
Rinse
Finishing

Figure 9. Typical Processing of 100 Percent Synthetic Fabric.

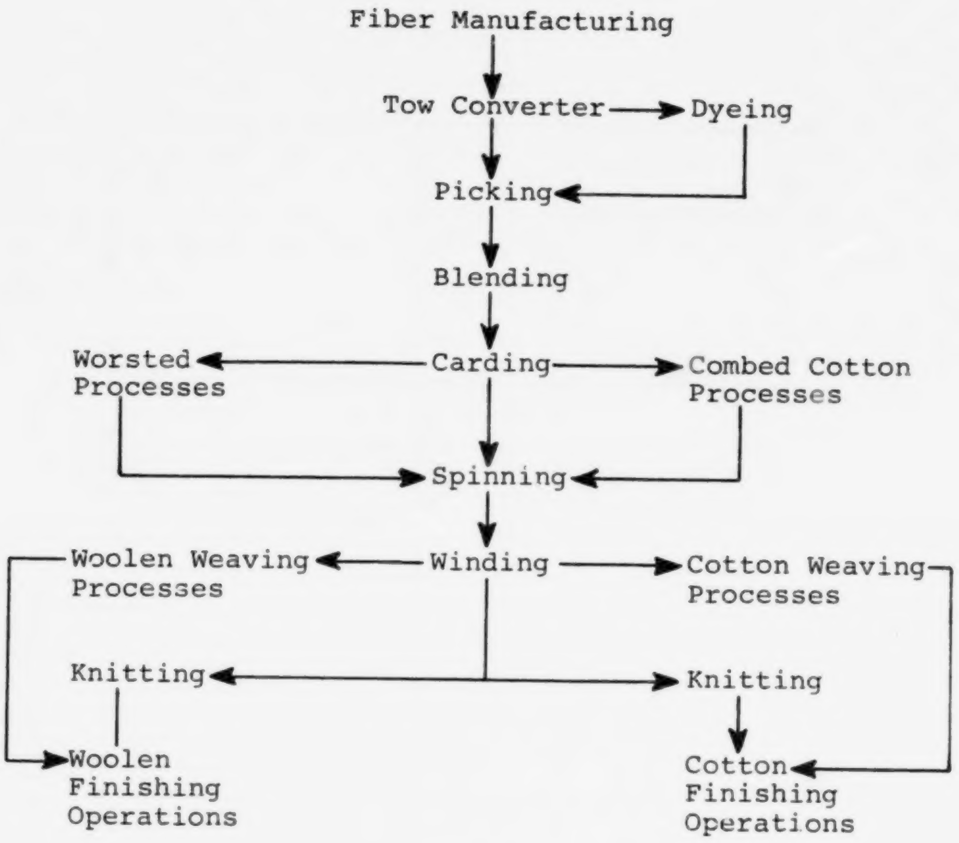

Fiber Manufacturing
Tow Converter
Dyeing
Picking
Blending
Carding
Worsted Processes
Combed Cotton Processes
Spinning
Winding
Woolen Weaving Processes
Cotton Weaving Processes
Knitting
Knitting
Woolen Finishing Operations
Cotton Finishing Operations

Figure 10. Typical Processing of Blended Fabrics.

Rayon

In finishing rayon, scouring and dyeing are usually done concurrently in a single bath. A solution of soluble oil and synthetic detergent is used for the scouring action. The same dyes as are used in cotton dyeing can be applied to rayon; however, lower temperatures (180° - 200° F.), retarding agents, and lower concentrations of electrolytes are used to effect exhaustion of color (35). The main reason for dyeing and scouring rayon in the same bath is that very little rayon is bleached, due to the degradation of the fiber by the oxidizing agents used in bleaching (31). A typical rayon scour and dye bath will contain the antistatic-lubricant used for weaving purposes and the soluble oil and synthetic detergent used in scouring (52). The average BOD in this bath is 2,832 p.p.m. of which 50 to 60 percent was contributed by the anti-static compounds, 30 to 40 percent was due to the soluble oil, and 10 to 20 percent was caused by the synthetic detergent (32).

After the scour and dye bath, rayon is subjected to a salt bath to remove residual scouring material and to assure fastness of the dyestuff. The bath contains a synthetic detergent and salt solution which is subsequently rinsed from the fabric. Practically all the BOD of this discharge is due to residual scour and dye bath solution left in the fabric. The waste discharge has an average BOD of 58 p.p.m. and a salt content of 4,000 to 12,000 p.p.m. (32).

If scouring and dyeing are the only finishing processes given rayon fabrics, the two baths will produce an equalized effluent of 1445 p.p.m. BOD and 2,000 to 6,000 p.p.m. salt contained in approximately 5000 gallons of water for each 1000 pounds of fabric processed (52).

Acetate

The usual procedure for processing acetate fabrics is as follows: a preliminary desizing action, if necessary; a scour and dye bath or scour and bleach bath, depending on whether colored or white fabric is desired; and two rinsings. The anti-static compounds are solubilized by diastatic or proteolytic enzymes prior to scouring (52). Soap or a synthetic detergent is used for scouring, and dyeing is done by dispersed dyes, dispersed developed dyes, acid and naphthol dyes (53).

Because dispersed dyes have very low solubility in water, they are applied as a fine dispersion of the dye. Sulfonated oil, aliphatic esters, and softeners are applied to each class of dye at a concentration of 0.02 pounds per pound of fiber to facilitate dyeing (53). When the fiber is swelled, the dye solution penetrates into the fiber. The rinses following dyeing remove the swelling agent, and as the fiber unswells, the dye solution is encased in the fiber (53).

If the bleaching is required, mild oxidizing agents such as peroxide bleaches and chlorine can be used. Usually a 3 percent solution of hydrogen peroxide is used as the bleaching agent (54).

The wastes from the scour and dye bath averaged 2000 p.p.m. and 50 pounds of BOD for each 1000 pounds of acetate fabric. The bath contained the anti-static-lubricant desizing wastes, which contributed 40-50 percent of the BOD load; the sulfonated oil swelling agent, which accounted for 30-40 percent of the BOD load; the aliphatic ester swelling agent, which amounted to 10 to 20 percent of the BOD discharged, and the softener which had negligible BOD content. The two rinses had a fairly low BOD content, resulting from residual chemicals remaining in the cloth from the scour and dye bath. These three processes produce a composite waste of 666 p.p.m. of BOD for each 1000 pounds processed; the volume of water required to treat this amount of cloth averages 9000 gallons (52).

If bleaching is substituted for dyeing, the BOD of the discharge of the scouring and bleaching bath is approximately 750 p.p.m. (52). The equilization of this bath with the discharges from the two rinsings will average 250 p.p.m. and 15-20 pounds of BOD in 9000 gallons of wastewater for the processing of 1000 pounds of cloth.

Nylon

The usual procedure involved in nylon finishing is scouring, two rinses, dyeing and another rinse. Nylon differs from other synthetics in that approximately 1 percent of the fiber dissolves when scoured. Nylon fibers can be dyed by every class of dye. When nylon is used in blended fabrics, the choice of dye usually depends on the other fiber component of the blend (52).

Soap and soda ash are used in the scouring process. When wasted, the bath contains the following BOD producing compounds - the anti-static compound, soaps, and fatty esters (from the dissolving fiber components) (32). The typical nylon scour bath averages 1360 p.p.m. and 34 pounds of BOD for each 1000 pounds of cloth processed. The substances present in the bath contributed the following percentage to the total BOD of the bath: anti-static-sizing compound (40-50 percent), soap (40-50 percent), and fatty esters (10-20 percent) (52).

When nylon is dyed, sulfonated oils are used as dye dispersants. These dye dispersants contribute practically all of the process's BOD, which amounts to an average of 600 p.p.m. and 15 pounds for each 1000 pounds of cloth dyed.

The two rinses between the scouring and dyeing processes and the rinse following dyeing are low in BOD, which is caused by scouring and dyeing process chemicals that remained on the fabric. If the wastes from these five processes are equalized, scouring and dyeing 1000 pounds of nylon fabric results in a waste stream which will average 346 p.p.m. and 43.2 pounds of BOD in 15,000 gallons of waste water (52). The BOD contribution of the scouring process is roughly 80 percent, the remaining BOD being contributed by the dyeing process (32).

Polyester

Polyester fabric finishing is usually carried out in the following order: scour, rinse, dye, and scour again. If blended fabrics are being processed, there is usually a second dyeing before the final scour. A non-ionic synthetic detergent is used for scouring.

Polyester may be dyed in several different ways. Conventional dyeing temperatures (room temperature to boiling) may be used, but carriers are needed to take the dye into the fiber. A second method eliminates the carriers, but high temperatures (250° F.) and pressures (50 psi) are required to get desirable results. Another method of polyester dyeing is thermosol dyeing, in which the fabric is coated with the dyestuff and cured on the fabric in an oven. Carriers used in polyester dyeing are: ortho-phenylphenol, biphenyl, benzyl alcohol, methyl naphthalene, and chloro-benzenes. To use these carriers at conventional temperatures, high concentrations of from 0.06 to 0.4 pounds of carrier to one pound of fiber are required (55).

The polyester scour wastes average 500-800 p.p.m. of BOD. The processing of 1000 pounds of polyester fabric will produce 15.5 pounds of BOD of which 90 percent is contributed by the anti-static compounds used for lubrication and sizing (32).

Because of the high concentrations at which they are used and the inherent high rate of BOD, the emulsifying and dissolving agents used in polyester dyeing will produce high BOD loads. Table IX lists the BOD loads in p.p.m. and pounds of BOD for some carriers used in polyester dyeing.

TABLE IX

BOD LOADINGS OF POLYESTER DYE CARRIERS

Carrier	BOD	
	p.p.m.	lbs./1000 lbs. of cloth
Ortho-phenylphenol	6,000	180
Benzoic Acid	27,000	810
Salicylic Acid	24,000	720
Phenylmethyl carbinol	19,000	570
Monochlorobenzene	480	14

Source: (Ref. 32, p. 38).

At the present time ortho-phenylphenol is one of the most widely used dye carriers. Chlorobenzenes find limited use because their toxic vapors cause health problems (52). The two rinses of polyester finishing are usually low in BOD as the result of chemicals held in the cloth after scouring and dyeing. The processing of polyester uses an average of 15,000 gallons of water (32).

Acrylics and Modacrylics

Although these two fiber - types have different physical and chemical properties, they are both subject to the same finishing techniques and can be discussed together.

The most prevalent methods of dyeing these two fibers are with acid dyes using cationic dyeing assistants, and with basic dyes using anionic assistants (56). The amount of carriers used in the bath ranges from 0.02 to 0.1 pound of chemical per pound of fiber dyed (32).

The waste from the first scour averages 2190 p.p.m. and 660 pounds of BOD per 1000 pounds of processed fiber. The chemical components of the bath are the antistatic compound, which accounts for 30-50 percent of the BOD, and the soaps used to accomplish this process. The rinse following the first scour contains the soap and lubricant solution held over from the scouring process and is usually low in BOD (32).

When using acid dyes, the dye baths average 175 p.p.m. and 5.3 pounds of BOD per 1000 pounds of fabric, the total BOD load coming from the dye carriers.

The final scour averages 668 p.p.m. and 20 pounds of BOD for 1000 pounds of cloth (52). This final scour is accomplished with synthetic detergents and pine oil, which together contribute practically all the BOD. Again, the subsequent rinse washes out held over solution and is relatively low in BOD.

The equalized discharges will have a BOD of 575 p.p.m. and 120.9 pounds in a volume of 25,000 gallons of wastewater for each 1000 pounds of acrylic and modacrylic fabric processed.

Wet Processing Wastes of Synthetic Fibers

Unlike wool and cotton, synthetic fibers of the same type can have different physical and chemical properties. The producers of man-made fibers are continually producing variations of existing fibers and totally new fibers to meet existing or anticipated needs. As a result of all this research and development work, the techniques used in finishing synthetic textile fibers are largely dictated by the fiber manufacturer. For these reasons, the processing of synthetic fibers can produce a variable wasteload depending on the particular fiber type used, the manufacturer's suggested method of processing, and the particular process chemicals used. Table X lists the pollutional loads and waste water volume generated in processing the five synthetic fibers discussed above. Table XI lists the significant pollutants found in the waste water resulting from these same processes.

Table X. Pollutional Load of Synthetic Wet Fiber Processes.

Process	Fiber	pH	B.O.D. p.p.m.	B.O.D. lbs./1000 lbs. of cloth	Total Solids p.p.m.	Total Solids lbs./1000 lbs. of cloth	Suspended Solids lbs./1000 lbs. of cloth	Volume in gal per 1000 lbs. of cloth
Scour	Nylon	10.4	1360	30-40	1882	30-50	20-40	6,000-8,000
	Acrylic/ Modacrylic	9.7	2190	45-90	1874	12-20	25-50	6,000-8,000
	Polyester	----	500-800	15-25	----	25-35	5-15	3,000-5,000
Scour & Dye	Rayon	8.5	2832	50-70	3334	25-39	0-3	2,000-4,000
	Acetate	9.3	2000	40-60	1778	-----	1-20	4,000-6,000
Dye	Nylon	8.4	368	5-20	641	20-34	2-42	2,000-4,000
	Acrylic/ Modacrylic	1.5-3.7	175-2000	2-40	833-1968	6-9	5-20	2,000-4,000
	Polyester	----	480-27,000	15-800	----	30-200	-----	2,000-4,000
Salt Bath	Rayon	6.8	58	0-3	4890	20-200	2-6	500-1,500
Final Scour	Acrylic/ Modacrylic	7.1	668	10-25	1191	4-12	3-7	8,000-10,000
	Polyester	----	650	15-25	----	10-50	3-50	2,000-4,000
Special Finishing	Rayon	----	----	20	----	3-100	3-50	500-1,500
	Acetate	----	----	40	----	3-100	3-50	3,000-5,000
	Nylon	----	----	10	----	3-100	3-50	4,000-6,000
	Acrylic/ Modacrylic	----	----	60	----	3-100	3-50	5,000-7,000
	Polyester	----	----	2-80	----	3-100	3-50	1,000-3,000

Sources: Ref. 32, p64; Ref. 33, p 101; Ref. 52, p 16.

TABLE XI

SIGNIFICANT POLLUTANTS IN SYNTHETIC FIBER WET PROCESSING

Fiber	Process	Liquid Waste Pollutant
Rayon	Scour & Dye	Oil, dye, synthetic detergent, and anti-static lubricants
	Scour & Bleach	Synthetic detergent, and hydrogen peroxide
	Salt bath	Synthetic detergent, chloride or sulfate
Acetate	Scour & Dye	Anti-static lubricants, dye, sulfonated oils, synthetic detergent, esters, and softeners
	Scour & Bleach	Synthetic detergent, hydrogen peroxide or chlorine
Nylon	Scour	Anti-static lubricants, soap, tetrasodium pyrophosphate, soda, and fatty esters.
	Developed Dispersed Dye	Dye, N_aNO_2, Hydrochloric acid, veloper, and sulfonated oils
	Bleach	Peracetic Acid
Acrylic/ Modacrylic	Dye	Dye, formic acid, wetting agent, aromatic amines, retarding agent, and sulphates
	Thermosol Dyeing	Acid
	Bleach	Chlorite
	Scour	Synthetic detergent and pine oil
	Thermosol Dyeing	Acid

TABLE XI Continued

Dyeing with carriers	Chlorobenzenes, hot water, and dye; or phenylmethyl carbinol, dye, and hot water; or ortho-phenylphenol and dye
Scour	Anti-static lubricants, chlorite or hypochlorite, and non-ionic synthetic detergents
High temperature & pressure dyeing	Dye and hot water
Bleach	Chlorite, N_aNO_2, acetic acid, oxalic acid, nitric acid, bisulfite, proprietary bleaches

Source: (Ref. 33, p. 93)

The Federal Water Pollution Control Administration has projected the gross wasteload expected to be produced by the synthetic textile finishing industry for the next twelve year period. These projections are based on the projected growth rate of the industry and on estimates of increased waste treatment and reduction of wastes per unit of operation (33). These projected figures are given in Table XII for 1970, 1971, 1972, 1977 and 1982.

TABLE XII

PROJECTED GROSS WASTELOAD AND WATERWASTE VOLUME FOR SYNTHETIC FIBER FINISHING WASTES FOR SELECTED YEARS 1970-1982

Year	BOD	Suspended Solids	Total Dissolved Solids	Volume (Billion Gals.)
	(Million Pounds)			
1970	288	291	584	28
1971	301	304	608	29
1972	314	316	633	30
1977	375	379	760	36
1982	409	412	827	39

Source: (Ref. 33, p. 102).

As noted in the introductory remarks of this section, the synthetic fibers are gaining a large portion of the total textile fiber market. The rather high growth rate anticipated (47) accounts for such high waste load predictions.

Special Finishing

In the past, special finishing was used to impart a smooth appearance and the desired stiffness to the fabric. Today, in addition to the above two purposes, fabrics are finished in order to obtain several other desirable properties. Among the properties desired are flame retardancy, water repellency, water proofing, mildew proofing, oil repellency, and the latest two convenience items, soil release and wash and wear.

The list of chemicals used for special finishing is rather long and will not be covered here. The American Association of Textile Chemists and Colorists has prepared a list of the 5-day BOD values for all textile chemicals (2). This list enumerates the uses of each chemical, and the ones used in finishing can be examined to see how much BOD they would contribute to the final wasteload.

At present there hasn't been any extensive research into the pollutional effects and loads produced by these processes; however, it is estimated that this process contributes 5 to 15 percent of the total plant BOD for all three fiber groups (33). Tables II and X list some values given by authors for special finishing of cotton and synthetic fibers; however, these values reflect a particular mill's discharge and may not indicate a true average value. The major reason for the scarcity of research data on this subject is probably that not all goods receive the same degree of special finishing, and that some, such as wash and wear rain coats, may receive several types of special finishing.

CHARACTERIZATION OF TEXTILE EFFLUENTS SUMMARY

From examining Tables II, IV, and X, it can be concluded that each of the three textile finishing groups produces a highly variable wasteload. The constant introduction of new fibers, finishes, chemicals, processes, machinery and techniques and an ever-changing consumer demand for different styles and colors of fabric are the principal causes of this variation.

The wastes from a textile finishing mill come from two sources: the natural impurities present in the fibers and the process chemicals used. In synthetic fibers, only the process chemicals are the source of pollution as they are relatively free of chemical impurities. In the processing of cotton and wool wastes, the natural impurities are the largest source of pollution, and are contained in a highly concentrated effluent.

Wool finishing wastes have high BOD loads, high solid concentrations, and a high grease content that arises from the scouring process. The wool wastes are usually considered the strongest textile wet wastes per gallon of process water used. The Federal Water Pollution Control Administration's predictions of future wool wet waste discharges (Table VIII) call for a slight increase in total BOD discharge; however, due to wool's low demand, these wastes will be the lowest for the industry. Although its waste is not as strong as that from the wool industry, due mainly to the absence of grease, the cotton finishing industry produces the largest volume of wet wastes. Cotton textile wastes can have high color content. The Federal Water Pollution Control Administration's gross wasteload projections are for a slight decrease in cotton waste discharges in the coming years (Table IV).

The synthetic fiber finishing wastes are lower in volume and concentration than the natural fiber wastes per gallon of water used. The synthetic fiber market's rapid growth has indicated that on a total volume basis, these wastes will be the largest for the industry in a short period of time (Table XII). One significant difference between synthetic fiber wastes and natural fiber wastes is the presence of toxic materials in the waste stream when dye carriers are used for synthetic dyeing.

REVIEW OF WASTE TREATMENT TECHNIQUES

Introduction

Waste water treatment processes may be categorized into groups which differ mainly by the number of operations performed on the waste streams: preliminary treatment, which is used to remove grit and solid material; primary treatment, which removes settleable and floatable solids; secondary treatment, which removes biodegradable organic matter; and tertiary treatment, which is used to remove materials that are resistant to secondary treatment. In addition to these conventional treatment processes are the newly developed chemical and physical treatment methods which may replace any or all of the above processes.

Preliminary and Primary Treatment

Preliminary treatment includes equalization, neutralization, and possibly disinfection of the waste stream, although this may be done at the end of the treatment process. Segregation of different streams is performed for several reasons, among them being these: the presence of toxic compounds that could upset the balance of bacterial growth in biological treatment; or the possibility of wastes such as storm drainage, sanitary and housekeeping wastes that require no pretreatment, being included with the industrial effluent that must be pretreated; and temperature differences which must also be equalized before further treatment.

Equalization or mixing of different wastes is used to insure that the variations and shock loadings are not introduced to the secondary treatment process. Variations in loading are eliminated by mixing highly concentrated waste with very dilute waste. The differences in production such as batch processing and the possibility of variation in the work week require equalization of waste streams to insure that the secondary treatment system, if biological, will not be damaged. If waste streams are not carefully controlled, lagoons used for equalization can become odoriferous and objectionable to the surrounding community. For this reason, modern installations provide aeration of the mixed effluent, to reduce the possibility of odor formation and at the same time lower the pollutional load as measured by five day BOD tests (57).

Neutralization will be necessary if the biological processes reach a pH higher than 10 (43). Direct discharge of acidic and alkaline waste can cause corrosion of pipes and sewer facilities. State regulations limit the range of pH allowable for discharge - to stream effluent. Table XIII lists some of the chemicals commonly used for neutralization.

TABLE XIII

CHEMICALS FOR NEUTRALIZATION

Acid Wastes	Alkaline Wastes
Lime Slurries	Sulfuric Acid
Limestone	Hydrochloric Acid
Soda Ash	Carbon Dioxide
Caustic Soda	Flue Gas
Ammonia	Sulphur
Waste Alkali	Waste Acid

Source: (Ref. 58, p. 34).

These chemicals can be added in either a batch process, or by automatic acid or alkaline dosing units.

Disinfection of waste waters may be required before discharging treated effluent to streams. This can be accomplished before primary treatment or as the final treatment step. When disinfectant is added before primary treatment it may have two effects: it may destroy some wastes that are toxic to the microbes in the secondary stage; secondly, it may prevent septic flox, pathogenic organisms, and undesirable algae from reaching the receiving stream. When the disinfectant is added as the final treatment step, it is done for this second effect. Chemicals commonly used for disinfecting waste waters include chlorine and several of its derivatives - - chlorinated lime, high test hypochlorite and chlorine dioxide, and ozone. Table XIV lists ranges of chlorine required for treatment of municipal waste waters.

TABLE XIV

CHLORINE EQUIVALENT REQUIRED FOR DISINFECTION

Status of Effluent	mg./1 Required
Raw Sewage	6-12
Septic	12-25
Settled Sewage	5-10
Septic	12-40
Chemical Precipitation	3-6
Trickling Filter, Normal	3-5
Trickling Filter, Poor	5-10
Activated Sludge, Normal	2-4
Activated Sludge, Poor	3-8
Sand Filter, Normal	1-3
Sand Filter, Poor	3-5

Source: (Ref. 59, p. 86).

State regulations usually require the higher quantity dosage associated with the poor effluent category, rather than the normal effluent category; for example, raw sewage is required to receive 12-25 mg./1. rather than 6-12 mg./1.

Screening (60,61,62) is used to remove the relatively large floating or suspended particles such as fibers, undissolved chemicals, dirt and grit from the effluent before further treatment. There are three general classifications of screens: coarse - with openings of 1.5 to 6 inches; intermediate - with 0.25 to 1.5 inch interstices; and fine screens with less than 0.25 inch openings. Screening media include equally spaced bars, woven wire, slotted or perforated plates. The solids that collect on the screens can be removed manually, mechanically, or by back-washing with water, steam, or air. Where a continuous discharge takes place, the latter two procedures are best. The screens are placed at the head of the drain pipes or another easily accessible place and function as the effluent is discharged through them. The paper and pulp, food processing, and steel industries are experimenting with vibrating screens, which may accomplish a higher degree of solids removal than conventional screens.

Sedimentation (63,64) uses the force of gravity to remove settleable solids from waste waters. The effluent is discharged to sedimentation tanks and detained there for a period long enough for sedimentation (65). Detention over a long period of time will cause scum and sludge build-up along with odoriferous conditions. Different tanks, including Imhoff tanks, can be used for sedimentation. The deciding factors are land space and sludge disposal requirements. In general the settleable solids are deposited on the bottom of the tank where they form a watery sludge, which is mechanically removed and disposed of. (The disposal of sludge shall be covered in a separate topic.) The tanks are covered containers which can accomplish both sedimentation and sludge digestion by anaerobic bacteria in the same vessel. Thus they have a decided advantage over open tanks and separate sludge disposal systems in small areas.

Flotation is another method of solids-liquid separation. This can be done by employing flocculation and dissolved-air flotation.

Flocculation (66, 67) utilizes chemical precipitation to cause separation. It can be used to increase the rate of sedimentation and flotation by dissolved-air processes, or as a separate settleable solids reduction technique. The principle of the process is to add organic and/or inorganic chemicals (depending on the waste characteristics of the effluent) to the waste waters. The solids in the waste collide with the coagulants, and the two are held together by molecular forces, thus increasing particle size. The resulting bulky gelatinous particles known as floc are removed by either sedimentation or floatation and possibly by a final filtering step.

The flotation process most commonly employed in waste treatment is that of dissolved-air flotation. Fine air bubbles, less than 100 microns in diameter, are introduced to the effluent, where due to surface interactions they become attached to the solid particles. As the air bubbles decrease the density of the solids, the separation takes place at the surface of the effluent, rather than at the bottom of the settling basin.

Secondary Treatment

Two treatment methods used to reduce the organic load of textile effluents are chemical separation and biological oxidation.

Chemical separation uses the action of chemical absorption or bonding to separate the dissolved contaminants from textile effluents. An advantage of this type of treatment is flexibility. When process chemicals are changed, the chemical coagulants can also be altered to handle the change in effluent composition. Common coagulants used in textile effluent applications are these: lime, sulphuric acid, ferrous sulphate, ferric sulphate, aluminum sulphate, ferric chloride, calcium chloride and ferric alum.

By this method of treatment the wastes are stored in a lagoon or settling basin for the proper removal of solids. The effluent is then pumped to rapid-mix basins where coagulants are added by automatic control devices. This rapid mixing causes flocculation and sedimentation to occur. After the floc is removed from the surface or settled to the bottom of the basin, the liquid is drawn off and discharged.

This treatment method for municipal wastes reduces BOD on the average of 45-50 percent and color 80-90 percent (68). The process, however, is not as economical as biological methods of secondary treatment. Chemical treatment methods require skilled technicians to assure that the proper chemicals are added in the proper dosages to the varying effluent.

Biological oxidation (69, 70) utilizes microorganisms to degrade the organic material in the waste stream.

There are two methods of biological treatment, classified according to oxygen requirements--aerobic and anaerobic. The first method uses microorganisms and free oxygen dissolved in the effluent to convert the wastes to more microorganisms plus energy needed for this existence. The microorganisms use the waste as food to develop and multiply; the same process that occurs naturally in streams and rivers. The microbes use the oxygen and convert the waste to carbon dioxide and water; a typical reaction with a carbohydrate would be:

$$C_6 H_{12} O_6 + 6O_2 \rightarrow 6CO_2 + H_2O$$

Another type of organism is used in the anaerobic digestion process. This process occurs without free oxygen available to the microbes. Bacteria ultimately convert most of the waste to methane and carbon dioxide; a typical reaction is:

$$C_6 H_{12} O_6 \rightarrow 3CH_4 + 3CO_2$$

Generally, aerobic digestion is preferred for two main reasons. The products of aerobic digestion are in a higher state of oxidation and anaerobic digestion can produce odoriferous hydrogen sulfide when sulfate or sulfides are present in the waste stream.

In biological processes, there are four process variables: BOD loading, oxygen and temperature requirements, and degree of mixing. In conjunction with these are five environmental variables: pH, nutrients, salts, toxic load, and variations in environment.

The BOD is a measure of the amount of organic matter in the waste, expressed in terms of the pounds of oxygen required for aerobic decomposition of the waste.

Oxygen requirements are given as pounds of oxygen per pound of biodegradable waste (generally referred to as BOD). The oxygen supplied must sustain a dissolved oxygen level of 0.5 to 1.0 milligrams per liter to insure adequate aerobic conditions; however, too much dissolved oxygen can encourage the growth of undesirable species (71).

Depending on the type of biological process being used, temperature requirements vary. For trickling filters, a consistent temperature of 85° F. is important for optimum results (57); if the temperature is lowered or raised, efficiency is adversely affected. This feature makes it difficult for trickling filters to operate at an optimum during the hot summer periods and cold winter days. Some activated sludges have been able to operate efficiently at 115° F. (71). With the activated sludge process, increases of temperature in the range of 50° F. to 115° F. afford a number of advantages: at higher temperatures, a fixed quantity of microorganisms can treat more BOD at the same time; flocculation and sedimentation are enhanced; less sludge is produced for a given BOD loading; sludge is less sensitive to adverse BOD loadings (71). The degree of mixing microbes and waste water can have a substantial effect on process performance. These higher efficiencies are achieved through more effective use of existing volume or creation of more surface area.

As stated earlier, the biological processes can not operate effectively at a pH above 10. The accepted range of pH values for biological methods is 6.5 to 9; microorganisms can be acclimated to perform well at any point within these limits, and will adjust to slight changes of pH over time; however, rapid changes in pH can retard their activity (71). High rate trickling filters are capable of operating at pH of 10.5 and activated sludge at pH 10 as an upper limit (57); however, any variation from these limits once the bacteria become acclimated, will cause lowering of process efficiency.

Biological growth requires several elements to sustain itself. The list includes carbon, hydrogen, oxygen, nitrogen, phosphorus, sulfur and trace elements of iron, calcium, magnesium, manganese, zinc, boron, potassium and cobalt. Natural waters contain sufficient trace elements, but sometimes lack nitrogen and phosphorus. These two nutrients can be added in two ways. Good results have been obtained in municipal treatment plants when domestic sewage which is high in phosphorus and nitrogen is mixed with textile wastes that are deficient these two elements (72). Also a mixing tank can be used in which ammonium phosphate is added to insure that the effluent contains nitrogen to carbon ratios of 1:20 or 1:10 and phosphorus to carbon ratios of 1:100 (43). If the process water has been chemically pretreated to remove hardness and other inorganic compounds (73, 74), a number of trace elements may also need to be added to the effluent before it is fed to the secondary process.

Salt present in the effluent will affect biological activity. It is therefore desirable to limit salt concentrations to less than 10,000 milligrams per liter (71). This may be a problem in some dye manufacturing operations but is not a problem with most textile waste streams.

Metal ions, phenolics, sulfides, cyanides and formaldehyde can be treated by acclimated cultures successfully, provided the concentrations are carefully controlled. For such control segregation and equalization would be required before biological treatment. Phenolics and formaldehyde are treatable in concentrations up to 1,000 milligrams per liter; sulfides and cyanides have been treated at concentrations less than 100 milligrams per liter, and metal ions present no problems when concentrations are 10 milligrams per liter or less (71). While the limiting concentrations given represent safe concentrations in most cases, complex waste streams may have toxic properties attributable to synergistic effects of specific mixtures.

Although microorganisms readily acclimate themselves to different environments, rapid pH changes or temperature movements of more than 5° F. per hour (71) are deleterious. Abnormal changes in BOD loading can cause adverse effects if there is not enough dissolved oxygen to handle the peak food supply.

There are four common biological treatment processes: stabilization ponds, aerated lagoons, activated sludge, and trickling filters.

Ponds and Lagoons

The stabilization pond is a basin 3 to 5 feet deep. The oxygen necessary for the biological process is supplied from the algae and surface aeration. To achieve high BOD reductions, the BOD loadings must be kept low, usually 4 to 10 pounds of BOD per acre-foot per day (71). Process efficiency varies with the season, as sunlight and temperature affect the growth of algae. The effluent is high in suspended solids and requires sedimentation before final discharge if this is to be the final treatment step. Liquid detention in stabilization ponds varies from 4 to 20 days depending on BOD loadings (71). The primary consideration with this process is the availability of a large area and remote location for the ponds. A large area is needed for the large volume of waste, and a remote location may be necessary due to the production of odors from the ponds in the summer season.

Aerated lagoons are similar in construction to stabilization ponds with the addition of mechanical aeration, which drastically increases the efficiency of the lagoon. The aerated lagoon has a depth of 15-18 feet, and the area requirements are about one-fifteenth of that of the stabilized ponds. The amount of oxygen required for efficient treatment is about 1 pound per pound of BOD (71). The aerated lagoon uses aerobic microbes and algae to perform the biological oxidation. The detention time for this process is 3 to 10 days, depending on the amount of oxygen supplied (43). Due to the large volume being treated at any time, shock loadings usually have much less effect on the system.

Activated Sludge

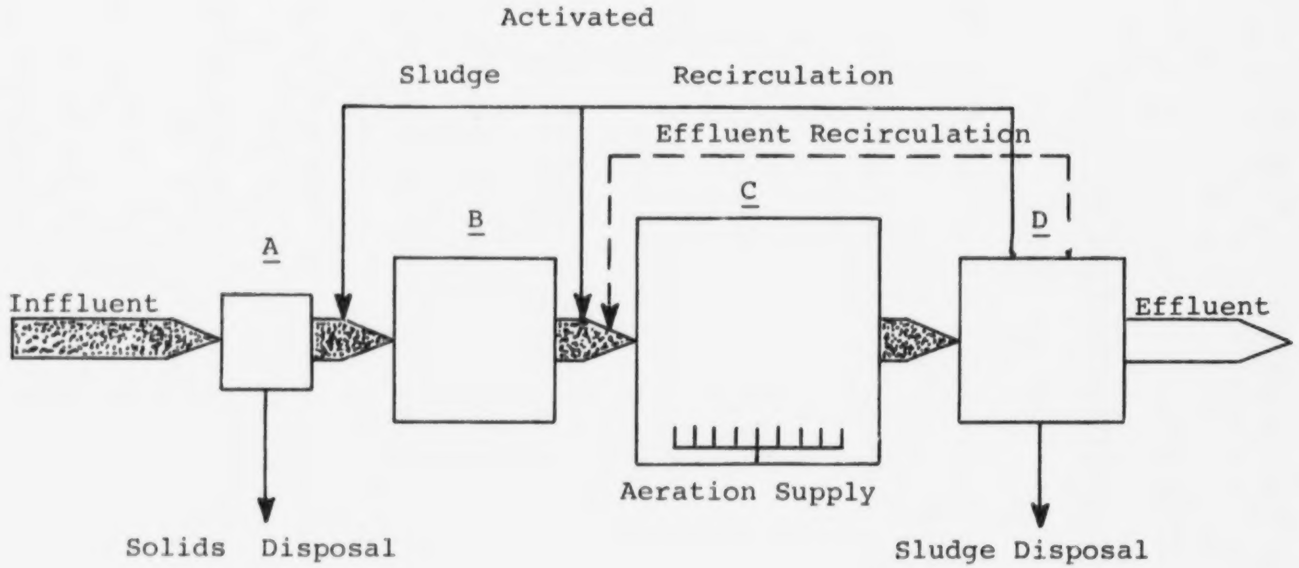
Activated sludge process involves mixing incoming waste water with biologically active sludge or suspensions of microorganisms. This mixture is aerated with compressed air or mechanical aerators for the desired length of time and then transferred into another tank where the activated sludge is separated by sedimentation. The isolated sludge is disposed of or returned to the process if needed. The treated effluent, which is relatively clear and odor free, with low BOD, low bacteria and suspended solids content, is then discharged to the receiving streams. Figure 11 is a schematic diagram of an activated sludge treatment plant.

The extended aeration type of activated sludge operation is designed for low BOD loadings, requires large quantities of oxygen, has detention times of 1 to 5 days, and produces the smallest amount of excess biological solids. The BOD loading parameters are 0.03 to 1.8 pounds BOD per pound of mixed liquor suspended solids (M.L.S.S.) per day. Oxygen requirements are 1.3 to 1.8 pounds per pound of BOD. The sludge waste, consisting of some waste particles and dead bacteria, will be 0.1 to 0.2 pounds per pound of BOD removed. The M.L.S.S. concentration usually maintained varies from 5,000 to 7,000 milligrams per liter. Due to long retention times and capacity of M.L.S.S. limits, the process is limited by the space available for operation ponds. Final BOD reduction with this method can be in excess of 95 percent, under ideal operating conditions (71).

Another activated sludge process called the conventional activated sludge technique is the most widely used for domestic sewage because of its simplicity. It affords a good BOD removal rate (90 percent). The BOD loadings required are 0.3 to 1.2 pounds of BOD per pound of M.L.S.S. per day; the oxygen requirements are 0.7 to 1.2 pounds per pound of BOD. The waste solids produced are around 0.35 to 0.55 pounds per pound of BOD removed. The M.L.S.S. concentrations are held at 2,000 to 4,000 milligrams per liter, and detention times run from 6 to 12 hours, depending on organic waste loadings (71).

A third activated sludge process called the high-rate process uses the least amount of space, requires the least oxygen, and has the lowest retention time. Because of these advantages it also produces the most excess biological solids and has the lowest BOD reduction rate (50-70 percent). The BOD loadings varies from 1.5 to 4.0 pounds of BOD per pound of M.L.S.S. per day; oxygen supply ranges from 0.45 to 0.65 pounds per pound of BOD. The sludge produced from this process is about 0.65 to 0.85 pounds of solids per pound of BOD removed. The detention time with this process is about 2 hours. M.L.S.S. concentrations should be held to about 1,000 milligrams per liter (71).

There are eight modifications of each activated sludge process which come about


Activated
Sludge
Recirculation
Effluent Recirculation
A
B
C
D
Influent
Effluent
Aeration Supply
Solids Disposal
Sludge Disposal

A. Preliminary Treatment

B. Primary Treatment

C. Aeration Tank

D. Secondary Settling

Figure 11 Activated Sludge Plant.

through different aeration techniques. They are summarized in Table XV.

TABLE XV

AERATION MODIFICATIONS IN ACTIVATED SLUDGE PROCESSES

Process Name	Modification
Hays Process	Incorporates a sedimentation stage between two periods of aeration.
Dual Aeration	Air is admitted at the bottom of the aeration tank and near the effluent surface.
Stage Aeration	The first stage is an activated sludge tank, and the second stage is a trickling filter.
Step Aeration	Return sludge is added to the mixed liquor at a number of points in the aeration tank.
Tapered Aeration	Air addition rate is inversely proportional to distance of effluent from entrance.
Contact Stabilization	Biological floc is contacted with effluent for only 1/2 to 1 1/2 hours. Separated floc is then reaerated. Used for effluents with a low soluble organic load.
Extended Aeration - Aeration Ditch	Extended aeration activated sludge is followed by long term (8 or more hours) aeration.
Mixed System	Combines sedimentation with mixed reactor and plug-flow reactor.

Source: (Ref. 37, p. 93).

Each of the above modifications has been used to increase aeration time and thus further remove BOD. Most of these modifications came about as a result of trying to increase process efficiency without increasing space requirements.

Another alteration of the activated sludge process is known as endogenous respiration. In this process the effluent is discharged into an aeration lagoon and seeded with activated sludge. The resultant mixture is aerated until most of the organic wastes have been oxidized. This eliminates the need for extensive sludge disposal and has been shown capable of oxidizing 60 pounds of organics in 1000 cubic feet of aeration lagoon (75).

Trickling Filters

Trickling filters or percolating beds (76, 77) contact the waste stream with the microbes and air by flowing the waste stream over a bed of rocks or synthetic media. Figure 12 schematically depicts a trickling filter installation.

The filter is usually a cylindrical tank packed with the filter medium (stone, coke, or synthetic material such as plastic) in such a way as to insure the presence of voids between the media pieces. The effluent flows onto the filter media by means of a rotating arm that distributes the waste load uniformly over the circular bed. The effluent trickles through the filter and over a slime of bacteria that adheres to the filter media. As bacteria die, they fall off the filter and are removed from the effluent during the secondary settling stage.

Trickling filters may be classified by filter media composition or method of effluent application onto the filter.

Filter media may be composed of rock or synthetic material. Stone, clinkers and coke are used for rock filters. The hydraulic loading of rock filters is usually 10 to 40 million gallons per acre per day; the BOD loadings are from 0.015 to 3.0 pounds BOD per cubic yard of media per day. The rock filters are 10 to 50 feet deep, requiring large land areas for settling and recirculation which is usually on a ratio of 1:1 or 10:1 raw waste to treated effluent (71).

The relatively new synthetic filter media have several advantages over the rock filter types. They are lighter than rock and can be stacked 30 feet high (78). The surface area per unit of volume is controlled when the media is manufactured so that more space for bacterial attachment is provided. The hydraulic loading can be as high as 200 to 400 million gallons per acre per day, and BOD loadings of 5 to 10 pounds per cubic yard per day (71) can be obtained.

The rate of effluent addition to the filter media may be standard or high rate loading. The difference is that the standard rate addition is intermittent loading periods of five minutes or less; whereas, high-rate types are continuously fed the waste stream by means of a variable recirculation system. The standard rate filter has a hydraulic loading of 4 million gallons per day per acre, organic loads of 15 pounds of BOD per acre-foot per day, and intermittent releasing of dead bacteria. The sludge from the process is a black, highly oxidized product containing light fine particles and a highly nitrified effluent with less than 20 milligrams of BOD per

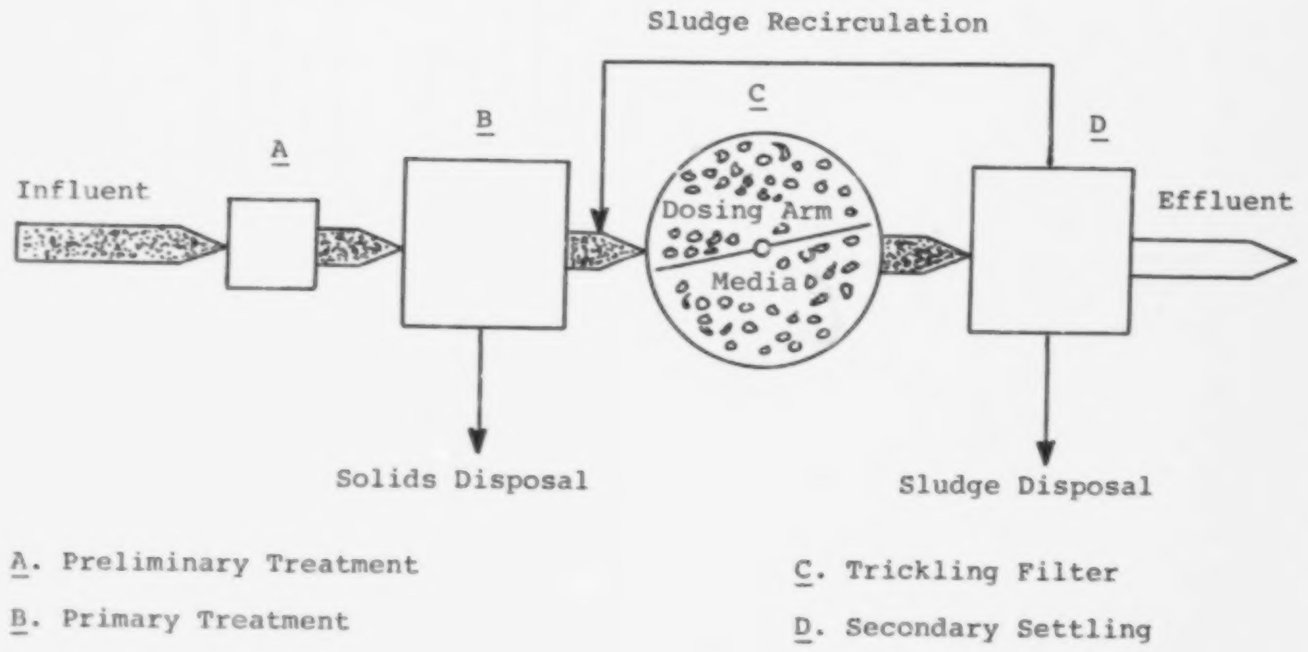

Sludge Recirculation
C
B
D
A
Influent
Dosing Arm
Effluent
Media
Solids Disposal
Sludge Disposal
A. Preliminary Treatment
C. Trickling Filter
B. Primary Treatment
D. Secondary Settling

Figure 12 Trickling Filter Plant.

liter. The effluent is usually discharged after one pass through the filter. The corresponding hydraulic load, organic load, and sludge discharge rate of the high-rate type are, respectively: 10-30 million gallons per day per acre, 30 pounds of BOD per acre-foot per day, and continuous. The sludge produced in the secondary settling tank is brown in color and not fully oxidized; the effluent is not fully nitrified and has a BOD of 30 or more milligrams per liter (59). Recirculating the effluent makes the final discharge as good as it is with the standard rate; however, the efficiency is lowered appreciably.

The term single-stage trickling filter refers to the process of passing the effluent through one trickling filter and then to a secondary settling tank. Two stage treatment refers to the passing of the effluent from primary settling through two trickling filters in series before the secondary settling stage. With single stage treatment, BOD removal is about 50-75 percent. The two stage method has a higher rate of BOD reduction (71) and is more costly than the activated sludge method (43).

Sludge Disposal

The biological treatment techniques produce sludge which ultimately must be disposed of. The simplest type of operation uses drying beds or sand filters on which the sludge is spread; the sand particles collect the solid matter while passing the water to an underdrain. The solid wastes can be incinerated, used for fertilizer, used as sanitary land fill, or buried in deep wells (79, 80). Care must be taken to avoid odor problems in hot weather. A second method of sludge disposal is digestion by anaerobic bacteria (81, 82, 83). The by-products of this method include the following: humus, used as fertilizer; sludge liquor that is recirculated in the secondary system to assure its purity before discharge; and decomposition gases. One research firm suggests the use of these gases as low grade fuel gas (59). A third method is vacuum filtration (84, 85). In this process, the sludge is passed under a vacuum pump which removes the solid content of the sludge and allows the water to pass through a discharge or recirculation drain. Finally, the sludge can be sent to an incinerator where the solids content of the sludge is burned (86, 87, 88 89).

Tertiary Treatment

At present this category of waste treatment is mostly in an experimental stage at industrial and domestic effluent treatment plants. However, these methods do bear discussion, for in the future legal standards concerning the quality of discharges will be raised to values exceeding the limits of conventional waste treatment methods.

Tertiary treatment processes may be classified into two broad groups: those that remove organics and those that remove inorganics from the effluent. Examples of organic removal processes are absorption, foam separation, and chemical oxidation.

Following are the inorganic removal processes: anaerobic denitrification, algae harvesting, ion exchange, electrodialysis, solvent extraction, reverse osmosis, freezing, ammonia stripping, and distillation. Table XVI lists some of these processes, their removal efficiencies, and estimated costs.

TABLE XVI

TERTIARY TREATMENT PROCESSES: REMOVAL EFFICIENCIES AND ESTIMATED COSTS

Process	Substance Removed	Efficiency (percent)	Costs (¢/1000 gal.)
Anaerobic Denitrification	nitrate-nitrogen	80-95	2-3
Algae Harvesting	nitrate-nitrogen	50-90	2-4
Ammonia Stripping	ammonia-nitrogen	80-95	1-3
Ion Exchange	nitrogen-phosphorus	80-92	17-25
Electrodialysis	dissolved solids	10-40	25-75
Carbon Absorption	organic material	90-98	4-8
Reverse Osmosis	dissolved solids	65-95	25-40
Distillation	dissolved solids	90-98	40-100
Foam Separation	surface-active-agent	-----	1-2

Source: (Ref. 90, p. 97).

Adsorption (91, 92, 93) uses highly adsorptive materials to partition waste impurities from waste streams. At present the most economical, efficient, and widely used absorbent is activated carbon. The carbon may be used as a batch or continuous process. In the batch process the entire bed of carbon is regenerated at one time. In the continuous process a moving bed is divided into a number of trays which are moved countercurrently through the tank by chain drive. When the tray loses its absorptive capacity, it is removed from the system and regenerated. Regeneration is accomplished by steam or incineration.

Foam separation (94, 95, 96) can be used when surface active agents are present in the waste water. In this process, compressed air is passed through the waste waters and a foam rich in surface active agents is produced. Removal of foam, normally by mechanical methods, accounts for eighty-five percent removal of the synthetic detergents present (90).

Chemical oxidation (37, 90) decreases the biological oxygen demand of the waste stream. In this way residual BOD in the effluent will not deplete the total dissolved oxygen content of the stream. Chemicals used are ozone, hydrogen peroxide, and manganese perchlorate, chlorine, sodium hypochlorite, potassium persulfate, sodium peroxide.

Anaerobic denitrification (98, 99) is used to remove nitrates (which are not degraded by the microbes of trickling filters and activated sludge) from waste water. An organic chemical such as methanol, ethanol, acetone or acetic acid is added as a carbon source to the effluent, which is then subjected to anaerobic digestion. The nitrates are reduced to nitrogen gas and nitrous oxide, which are released to the atmosphere as gas. The treated effluent is withdrawn after several days retention time and aerated without producing any waste products that require disposal (90).

Algae harvesting (100) is a method of biologically removing nitrogen and phosphorus compounds from the effluent. The effluent is deposited in shallow earthen ponds, where the algae convert the above compounds into cell tissue. The algae is then removed from the waste stream.

Ion exchange resins (9, 10) can be added to the effluent to remove inorganic ions such as salts, nitrates, and phosphates. The cations are exchanged for hydronium ions, and the anions are exchanged for hydroxide ions.

Electrodialysis (102, 10) is another type of ion separation. It uses an electrical potential rather than ion exchange to perform its function. The effluent is subjected to an electric potential which separates the waste into positive and negative components. The positive components are attracted to a negative membrane, and the negative components are attracted to a positive membrane, leaving a relatively pure solution between the membranes. Usually recirculation is required to get a high degree of dissolved solids removal.

Solvent extraction (57) is accomplished by the addition of an immiscible solvent to the waste water. The liquids are mixed together with high speed agitation and then separated. Organic impurities are removed from the water and transferred to the solvent. To date, very little research is available on the efficiency or cost of this process.

A new technique used for water purification and suggested by DuPont (104) for industrial waste water recovery is the reverse osmosis process (29, 105). Wastes are removed from the effluent by use of a semipermeable membrane, usually constructed of cellulose acetate or hollow nylon fibers and subjected to 350-600 pounds per square inch pressure, which is much in excess of the osmotic pressure of the solution. This causes the passage of water from an area of greater concentration to a solution of lower concentration. The solvent, in this case water, is passed through the membrane, while the impurities are collected at the membrane's surface. Since reverse osmosis can remove up to 95 percent of the dissolved solids content, it looks promising even though it is presently expensive, as shown in Table XV.

There exist two physical methods of obtaining very pure waste water-freezing and distillation. Both produce an almost pure waste free second phase from a high pollutional liquid phase. In freezing (57) the pure water collects as ice crystals on the surface of the waste water, while the impure compounds remain in solution. When ice crystals are removed and thawed, the water is very pure. Distillation (106, 107) separates the wastes from the water through a liquid-vapor conversion. The water is converted to steam, leaving non volatile waste behind. When it is condensed back to liquid form, it is very pure.

Ammonia stripping (108, 109) is a method of removing nitrogen from waste water. At a pH of 9 or more, ammonia is liberated as a gas by stripping towers. The process required 400 cubic feet of air per gallon of waste water in order to achieve high efficiency (90).

WASTE TREATMENT TECHNIQUE SUMMARY

Due to the variations in textile effluents from process to process, and from hour to hour, it would seem almost necessary to have some sort of preliminary treatment at most plant sites. This is especially true where the effluent is being discharged to a municipal sewer to avoid shock loadings to the treatment plant. Neutralization and equalization have been proved beneficial if the firm has its own secondary biological treatment plant.

Primary settling is also advantageous to biological treatment, not only because it removes solids that would take a long time for the bacteria to digest, but also because it avoids clogging of drain lines and flooding of tanks. Sedimentation and screening can also have economic advantages in that usable fibers may be recovered.

In secondary treatment of municipal waste the biological processes have proved to be more efficient and lower in cost than the chemical precipitation methods. As for the use of trickling filters or activated sludge, it is hard to determine what criterion has been used to choose between the two processes. Trickling filters require more area than activated sludges and are more expensive to build;but they are generally easier to operate, have lower operating costs (flow is by gravity rather than pumping), and are more resistant to some types of shock loading. Activated sludge is generally more economical for removing greater than 90% BOD. Chemical treatment can be more economical for removing total organic loading when the waste stream is only partially biodegradable.

At present, very little tertiary treatment is done at textile mills. One reason is the added expense; another is that conventional treatment can reduce the effluent to standards of 80-85% removal of oxygen demanding contaminants. However, in the future this type of treatment will become necessary to remove the many non-biodegradable chemicals in the industrial waste stream.

TREATMENT OF TEXTILE EFFLUENTS

The disposal of textile water wastes may be accomplished by two methods which are acceptable to state agencies. The first method is to discharge them to municipal sewer systems. The second method would be treatment of the wastes in a plant-owned facility and discharge to a receiving stream. Discharge of untreated wastes to a stream or other body of water is not acceptable.

Methods commonly used to neutralize effluents, to remove suspended solids, and to oxidize organic substances in effluents were described earlier. In this section, these methods of waste treatment and their application to textile wastes will be discussed in order to determine the methods best suited for particular textile water wastes.

In order to determine the most practical and economical waste treatment scheme available to a particular mill, the composition and volume of the mill's effluent must be known. This is accomplished by analyzing the mill's wet processing operations.

Pollution Survey by Analyzing Effluents

Chemical and biological characteristics of a waste stream are commonly determined by monitoring the stream over a period of time long enough to establish the average composition and typical variations.

Pollution Survey by Analyzing Wet Processing Operation

A simplified waste survey technique for the textile industry has been suggested by three New England Interstate Water Pollution Control Commission consultants (32). Their suggestions are incorporated into this section.

Their technique requires the evaluation of four waste producing variables. These variables are:

1. Pounds of fabric passed through each process
2. Water consumption for all processes
3. Pounds of chemicals used in each process
4. Pollution contribution of the impurities removed from the fabrics, and the process chemicals used in production

They recommend that the survey be limited to processes that use over 5 percent of the total poundage processed; for those processes that use less than 5 percent, only the volume of water consumed is required, since these generally produce negligible contribution to the impurities in the stream.

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As mentioned in the previous chapter, the total waste load from textile processing is contributed by two sources - the natural impurities removed from the fiber and the process chemicals used in removing these natural impurities and in finishing the fabric. Therefore, the total waste load can be calculated by adding together the waste load of the process chemicals and the waste load due to the natural impurities.

The BOD load of process chemicals can be determined by examining the American Association of Textile Chemists and Colorists' BOD list of textile chemicals (2), or by conducting BOD tests on those process chemicals which are not contained in this listing. In the list the BOD's are given as percentages; the results of a BOD test are given in milligrams per liter or parts per million. Dividing by the factor 10,000 converts milligrams per liter or parts per million to percentage values (2). These figures can be converted into pounds of BOD by the following formula (32):

$$\text{BOD (Pounds)} = \frac{\text{pounds of chemical used} \times \text{BOD percentage}}{100}$$

The pounds of chemical used can be determined either by examination of process formulae or by an inventory survey. The total BOD load produced by the process chemicals may then be calculated by adding all the process chemical BOD contributions together.

In order to calculate the waste loadings of the impurities and chemicals, samples are taken of the baths and rinses used in the scouring, desizing and bleaching, dyeing and finishing processes. These samples are analyzed to determine the weight of the impurities produced; process formulae will indicate the amount of chemicals that will also be present in these baths. The samples are tested to determine their COD, TOC, BOD, pH, and alkalinity value. Other tests may also be necessary.

The concentration in terms of parts per million of milligrams per liter of the natural impurities and the process chemicals can be calculated by the following formula (32):

$$\text{Concentration (p.p.m.)} = \frac{\text{pounds used}}{\text{total gal. discharged}} \times 120{,}000$$

The total gallons discharged is considered to be the total water consumption for the survey period. This factor can easily be determined from water meter readings or process formulae.

The BOD contribution in parts per million or milligram per liter of the impurities and the process chemicals can be calculated by the following formula (32):

$$\text{BOD (p.p.m.)} = \text{Concentration (p.p.m.)} \times \frac{\text{BOD percentage}}{100}$$

After evaluating four factors and making the necessary calculations, a picture of the waste composition and volume of the plant's effluent is obtained. Once this is done, the analyst will be able to select the most economical and practical waste reduction scheme based on the requirements imposed by the regulatory agencies.

Waste Reduction Through In-Plant Measures

After successfully completing a pollution survey, the analyst should determine if the waste load generated by the plant can be reduced. Significant reductions in the waste load could lead to the elimination of costly treatment facilities and processes. Six in-plant measures can be checked to see if the waste load can be reduced: reduction of wastewater volume, reduction of process chemicals, recovery and reuse of process chemicals, process modifications, substitution of process chemicals, and good housekeeping.

Reduction of Wastewater Volume

The first in-plant measure is the reduction of waste water volume. The main advantages of this procedure are reduction in water purchasing costs and the concentrating of the effluents in a smaller volume of water. The two procedures most commonly used to achieve this reduction are counter flow processing and water reuse techniques.

In counter flow processing, the water flows through the process in the direction opposite to movement of fabric. This scheme can be employed in operations that work on the continuous flow principle, for example, the rinses following bleaching of cotton and the scouring train in wool processing. By the time the fabric reaches the last unit, it should contain the least amount of natural impurities and/or process chemicals. Fresh water is used to remove this small amount of waste material and then, containing this small amount of waste, it is advanced to the preceding unit and used to rinse fabric containing a larger quantity of waste matter. The process is contained until the water is finally used in the first unit of the process. At this point the water may be discharged or used to make up the process bath (110).

Another way of reducing the volume of waste water is to use the same water several times before discharging it. This scheme can be used for batch processes, where the contents of one bath can not be forwarded to a preceding bath. Process water can be reused in the same process or in other processes. For example, waters used to rinse fabrics after dyeing can be used to make up a new dye solution, or mercerizing wash waters can be used to prepare scour, chlorine bleach, and "wetting-out" baths (57). When process water is reused it is usually circulated through filtering or settling devices to remove impurities from the water.

When reusing process water or employing counterflow processing, care must be taken to assure that any substances that could affect the ensuing textile processes are effectively removed. Fluorescent brighteners in concentrations as low as 0.5 milligrams per liter, some finishing agents, and salt compounds can leave residues on the fabric which will lead to undesirable results during further processing (111).

Reduction of Process Chemicals

It has been estimated that over 90 percent of the pollution load of textile wastes is contributed by the process chemicals (112). Therefore, reducing the amount of chemicals used in textile processes will lead to lower pollutional loads. Another benefit of reducing the amount of process chemicals is the consequent lowering of production costs.

Very often a large margin of safety is used in textile mill operations to eliminate the need for reprocessing. As this condition prevails only 1 to 5 percent of the time (32), it is possible to reduce this margin without impairing the quality of production. Careful study of the various textile processes should be undertaken in order to reduce the over-all quantity of process chemicals to the minimum necessary to ensure the required results. Through such studies it may be possible to reduce the amount of process chemicals usually used in washing, dyeing, etc., by one-fifth to one-half, thereby reducing the pollutional load on the order of 30 percent (32).

Recovery and Reuse of Process Chemicals

The reduced pollutional loads and production cost savings mentioned in the previous section can also be realized by recovering and reusing process chemicals instead of wasting them when the process is finished.

The two areas in which this action has proved most favorable are the recovery of caustic soda in cotton processing and the wool grease recovered in wool scouring. Caustic soda is recovered from the mercerizing and scouring processes; consequently it contains the natural impurities removed by the cotton which can be removed by dialysis or centrifuging and evaporation. In dialysis (115), the caustic solution is filtered to remove the insoluble natural impurities and then dialyzed to remove the soluble ones. In the other recovery technique, the solution is subjected to a centrifuging operation which removes the impurities and then subjected to a series of evaporators that concentrate the solution (110).

In the wool scouring, the wool grease can be recovered by the acid cracking process, centrifuging, or by solvent extraction. In the acid cracking process, the scouring liquor is acidified with sulfuric acid and well mixed until the grease separates from the water and is then recovered by pressure filtering (116). In the centrifuging process, the liquors from the first scouring bowl are subjected to high speed centrifugal separation which removes a high proportion of the grease from the water (45). Solvents such as aviation gasoline, naphtha, trichlorethylene, benzene, and carbon tetrachloride are used in solvent scouring of wool to remove the wool grease in a non-aqueous medium.

In the early 1950's efforts were made to recover dyes and accessory chemicals by adsorption on fuller's earth and activated bauxite followed by solvent extraction, but at that time were found to be impractical and unprofitable (117).

Process Modifications

The changing of processes and material flow procedures is another way of eliminating unnecessary wastes. Continuous operations generally require smaller space, use less water and process chemicals; the consequences of the last two advantages have already been discussed. Whenever possible, separate operations should be combined, such as scouring and dyeing in the finishing of synthetic fibers (51), and the desizing and scouring of cotton fibers (113). Another method of process change is to substitute standing baths and rinses for running ones, thus conserving water and concentrating the wasteload in the bottom of the process unit (57).

One drastic process modification is not to discharge the effluent at all, but to pump the process liquor to a storage tank where it is stored and saved for reuse in the make up of the next similar bath (68). Akin to this modification is the use of heat exchanges to transfer the high temperature of some effluents to incoming process water, thereby conserving water heating costs and reducing the possibility of thermal pollution (118).

Another process modification is the use of solvent processing. Although the scouring of wool by the solvent method has been done for a long time, large scale scouring and desizing of cotton and the dyeing and finishing of all types of fibers has been predicted for the future (119, 120, 121). When expounding the virtues of this new type of processing, the authors place as much emphasis on the consequent reduction of water pollution, due to the fact those solvent systems mentioned use little or no water, as on the efficiencies of the process. Besides accomplishing desizing dyeing and finishing in shorter time than by conventional aqueous systems (119), the new non-aqueous systems reduce the pollutional load. They do this by collecting the soluble natural impurities as an oily semi-solid at the solvent purification stills, rather than discharging them to waste, and by eliminating the highly alkaline and soap-laden effluent from cotton scouring and desizing and reducing the fresh water requirements from 15 gallons to 1/2 of a gallon (120). If all of the solvent is not recovered, however, a more serious air or water pollution problem may result.

Substitution of Chemicals

One method of reducing the BOD load of the mill is to substitute low BOD process chemicals for ones that have high BOD values. By again consulting the BOD list of textile chemicals (2), the analyst can determine which low BOD chemicals can be exchanged for those with a high value of BOD.

Three classical examples of process chemical substitution exist in the textile industry - the substitution of synthetic warp sizes (1 to 3 percent BOD) for starch (50 percent BOD) and gelating (100 percent BOD) in cotton slashing operations; the substitution of ammonium sulphate, chloride, or mineral acids (0 percent BOD) for acetic acid (33 to 62 percent BOD), and low BOD synthetic detergents (0 to 22 percent BOD) for soaps (140 percent BOD) (32). In wool processing, the traditional carding oil, olive oil, which has a 100 percent BOD value, has been replaced in some mills by mineral oils with nonionic emulsifiers that have a 20 percent BOD value (32). Again the mill must be sure that the low BOD chemicals are not more harmful than high BOD chemicals.

Other possible chemical substitutions have been suggested. The use of sulfuric acid in place of soap in wool fulling operations has been suggested by one group of researchers. Not only does sulfuric acid have no BOD, but when used in conjunction with synthetic detergent washing, the combined waste is highly acidic instead of highly alkaline (32). The substitution of steam ranges for the oxidation of dyes in place of dichromate-acetic acid baths, the use of low BOD dispersing, emulsifying and leveling agents in place of their high BOD counterparts in dyeing will decrease BOD loadings (51).

The substitution of low BOD process chemicals for high BOD ones has two drawbacks. One is the increased cost usually associated with these products (32). The other drawback is that while these chemicals have low five-day BOD values, little is known about their long term effects on aquatic life and waste treatment costs downstream (57). Careful study of the ultimate decomposition of these chemicals should be undertaken before they are indiscriminately substituted for high BOD compounds.

The substitution of synthetic detergents for soap presented treatment problems for textile wastes in the early 1960's. The typical synthetic detergent used prior to July 1965 was the alkyl benzene sulfonate surfactant type, commonly referred to as ABS. This synthetic detergent exerted no BOD (0 percent) on the receiving stream (18), but was non-biodegradable and therefore passed into the receiving stream unaltered. The presence of ABS in streams gives rise to foaming conditions (122) which were objectionable and hard to remove. Soap, on the other hand, is thoroughly decomposed by biological treatment (123). Since June 30, 1965, the detergent industry has switched to the production of biodegradable synthetic detergent of the linear alkylate sulfonate type, commonly known as LAS. These compounds are converted to new biological cell tissue by aerobic oxidation and removed from the effluent by settling tanks (124). The additional BOD exerted by using biodegradable detergents is only five percent over loads exerted by wastes containing non-biodegradable synthetic detergents (18). For the most part, textile surface active agents are of the "soft" or biodegradable type (122), thereby eliminating a major waste treatment problem.

Good Housekeeping

Another method of reducing the pollutional load of a mill and concurrently reducing production costs is good housekeeping. One method of good housekeeping is to maintain close control over the mill's operations, in order to avoid accidental spillages of process chemical baths and the preparation of too large a batch, the excess of which might be wasted. If accidental spillages of toxic chemicals occur, a good housekeeping practice is to dilute the spillage sufficiently to prevent shock loads from reaching the treatment facility (57). If the possibilities of picking up dirt, grease, rust, etc., from the floor and the machinery are eliminated, less washing and less processing of the fabrics are required (32).

A plant can be engineered for minimum losses through spillage, breakage, etc., by the incorporation of retaining walls, splashboards, and sills, but effective housekeeping depends on the efforts, cooperation, and support of the operating personnel to implement these procedures to the fullest extent possible in order to reduce the mill's pollutional load (68). It has been estimated that conscientious good housekeeping practices can eliminate from 5 to 10 percent of the total pollutional load of a textile mill.

By instituting a number of these in-plant pollutional load reduction techniques, a textile mill can reduce its effluent BOD considerably. Many state regulations require 75 percent or better BOD removal. Although the in-plant reduction procedures do not provide the required reduction percentage, they should still be employed as they reduce the waste load to its lowest level, provide the waste analyst with information he needs to select the most practical and economic waste treatment scheme, and, as a bonus, lead to reduced production costs.

Discharge of Textile Wastes to Municipal Sewers

The simplest and sometimes most economical method of treating a textile waste is to discharge it to a municipal treatment facility (37, 112, 128). If the aforementioned in-plant reduction guidelines have been followed properly, the mill's waste may be clean enough or low enough in volume to be treated by the municipal plant at little or no extra cost; and even if preliminary or primary treatment is required, the cost to the mill will be much less than if a complete treatment facility was required (129). A permit issued by the sewer authority is usually required for this privilege, which allows the authority the power to collect sewage service charges. These service charges are usually based on the volume of waste water discharged to the municipal facility, the volume of water consumed by the mill, the BOD output of the mill, or that portion of the extra costs involved in providing for the treatment of the textile effluent (57, 130).

In cases where a municipal facility exists and a textile firm wishes to connect to it, the existing plant may have to be expanded to handle the increased load, or the authority may place limits on the firm's discharges to the sewer. When the municipal plant is of the activated sludge type, the addition of trickling filters ahead of the aeration units is one method of enlarging the capacity; for trickling filter plants extra trickling filters or a chemical coagulation process can be added to the existing plant (37). The authority may set limits on the rate of flow and the temperature of the effluents discharged to their facilities. Other restrictions that may be imposed by the municipal plant are the neutralization of highly acidic or highly alkaline wastes, the reduction of toxic materials to very low concentrations, and the limiting of the concentrations of BOD and suspended solids. Exact values for these limits vary from one municipality to the other, depending on local conditions and the size, standards, and desired uses of the receiving watercourse (37). Therefore, unless the effluents produced by the mill do not meet these restrictions, equalization and/or preliminary treatment will be required in order to prevent the introduction of shock loadings to the system. If both textile mills and municipalities are located in an area in which there are no treatment facilities, and if the industrial waste stream can be treated by the municipality, a joint venture into the construction of a facility for combined treatment of the wastes is more economical and feasible than the construction of two separate facilities (37).

Another economic advantage in constructing a combined facility is that through Section 8 of the Federal Water Pollution Control Act, the municipality is able to receive construction grants from the Federal and State Governments. This typically amounts to 30 percent of the costs, leaving both the city and the plant responsible for only 70 percent of the costs (112).

There are three advantages to treating textile wastes in combination with domestic sewage (37). The first advantage of combined treatment is the economy of the operation. It reduces the capital outlays associated with waste treatment by providing a more economical operation and eliminating administrative costs. The second advantage is that combined treatment enhances the biological waste treatment processes, because domestic sewage contains the bacteriological nutrients (phosphorus and nitrogen) which may be absent in textile wastes. Finally, in combined treatment, the dilution of the textile wastes by domestic sewage weakens the concentration of the former, thus increasing process efficiency and preventing shock loads of toxic materials from killing the bacteria in the treatment plant.

Although the ratio of domestic sewage to textile wastes has no appreciable effect on the treatability of the wastes, a minimum of 7 parts of domestic sewage to 100 parts of textile waste is necessary to insure that the proper amounts of nutrients are supplied to the bacteria in the system (131, 132). The plant must also remember that when it depends on municipal waste treatment it is subject to their regulations and cost.

Plant Owned Facilities

If there is no possibility of discharging its effluents to a municipal sewer, the mill must construct its own waste treatment facilities, which would include preliminary, primary, secondary, and possibly tertiary treatment. In releasing its effluents to a municipal facility, a mill may also be obligated to install its own preliminary or primary treatment facilities.

For textile wastes the three preliminary steps used to ensure proper treatment of effluents whether by municipal or plant-owned systems are segregation, equalization, and neutralization. These systems were presented earlier and have obvious advantages.

Textile wastes vary tremendously due to the different processes, the variety of process chemicals used, and the inconsistent rate of discharge flow. Therefore, it may be desirable to make the waste as uniform as possible to assure proper operation of the treatment system. Equalization of the wastes accomplishes this objective by mixing and storing the effluent in ponds or basins. One approach is to use three basins or ponds on a fill-and-draw three-cycle system. With this arrangement one basin is receiving raw wastes, the second is thoroughly mixing the effluent, and the third is supplying effluent to the treatment system (128). The reason for suggesting this procedure is that textile waste liquors were found to have density variations caused by the variations in temperature and composition of the effluents. These variations cause low density, high-temperature liquids to lie near the surface and pass through gravity flow tanks quickly, while the high-density low-temperature liquids settle to the bottom and remain in the tank for longer periods of time, thereby negating the advantages of equalization.

The mixed liquors discharged from textile processing mills are generally alkaline and may require neutralization. Neutralization to pH 7, however, is not necessary; the amount of pH adjustment needed depends on which biological treatment process is being used. If chemical coagulation is used instead of biological oxidation, the pH adjustment will depend on the stream standard. The chemical agents for neutralization are sulfuric acid and carbon dioxide (134). The sulphuric acid is usually added to the effluent by automatic dosing units. Carbon dioxide can be added in two ways. First, carbon dioxide produced during aerobic biological oxidation (44) is suitable for alkali neutralization. Secondly, flue gas can be a source of carbon dioxide for neutralizing. The alkaline wastes flow down a steel tower through which carbon dioxide gas, burned as fuel, rises causing the neutralization to take place in the tower (115, 135). This method must be preceded by a screening and sedimentation operation to remove solid matter (136), and an antifoaming agent must be added when surface-active agents are contained in the liquor (134). Neutralization is likely to be most effective if the strong alkaline liquors are separated from the rest of the waste and neutralized in a segregated basin (136).

Screening and sedimentation are the two types of primary treatment used for textile wastes. Screening is necessary in order to remove solid wastes such as lint, fibers, grit, and dirt from the effluent. If allowed to remain in the waste stream, the solids would clog sewers, cause interference in subsequent treatment processes, and even end up in the receiving stream.

Stationary screens, if not properly maintained, will clog drains and cause stoppages and backups. Two developments to combat this nuisance have been used in textile facilities. One is the use of fine mesh vibrating screens (129); the other is a Swedish process in which a current of liquid, which flows away from the filtering screen, catches up the solid matter, then is fractionated and returned to the system (128). Sedimentation is important for removing suspended settleable solids from the effluent, but it can not eliminate the dissolved and non-settleable impurities which comprise the major proportion of the pollutional load present in most textile effluents. When biological oxidation is used as secondary treatment, some solids can be removed after treatment along with the sludge from the process (111, 117).

Secondary Treatment

Every state water pollution control agency requires this type of treatment for discharge of effluent to their state's waters. Secondary treatment involves the oxidation of organic matter by aeration, chemical, or biological methods or a combination of each.

When wastes are stored and held in equalization and sedimentation basins, they may become subject to anaerobic decomposition which tends to produce fecal odors (37). By maintaining a pH's high enough to prevent the loss of mercaptans, etc., in conjunction with aeration, this condition can be alleviated. Another reason for aeration is that the wastes may contain easily oxidizeable organic and inorganic matter, which can be oxidized by the air supplied to the wastes. Whether or not this is the most economical place to aerate must be determined from pilot studies.

Aeration can also be used as a post or "polishing" treatment on treated effluents to produce a final effluent that has a higher degree of clarity than obtained by the biological treatment alone (37).

Chemical coagulation has been used to reduce the BOD load of strong textile wastes by 30 to 50 percent (128). In wool processing chemical coagulation has been used extensively, and is considered a necessary pretreatment step for the removal of unrecovered wool grease from wool scouring effluents prior to biological treatment (33, 136). This process has been suggested as a method for removing toxic synthetic fiber dye wastes from the effluent prior to using biological treatment. In cotton wastes treatment, chemical coagulation has been used to reduce the load on subsequent biological treatment processes or as a "polishing" process on treated effluents (37). Research has shown that alum (aluminum sulfate) gives good coagulation of solids when used near a pH of 7 (136).

Three methods of biological treatment are used on textile wastes--anaerobic decomposition, mechanically induced aeration, and natural aeration.

Anaerobic decomposition can be used with wastes of high BOD concentration (2000 p.p.m. and up) (32). This would mean that the equalized effluents of any textile waste mill would be less effectively treated by anaerobic processes. Anaerobic digestion could be used on the segragated and highly concentrated wastes from the wash after fulling in wool processing wastes (138). In this connection it is usually used as a pretreatment step prior to aerobic processing (136).

The two most widely used biological treatment methods involving aeration are the activated sludge and trickling filters. Both processes can treat soluble BOD very effectively if the pH is adjusted to the acceptable limits, temperature is held fairly constant, the organic matter is biodegradable, toxic elements are absent or within tolerance limits, and the proper dosage of nutrients is present (32).

The most popular biological system used for treating textile wastes is the activated sludge extended aeration process (112, 127). If this process is properly used and maintained, a major portion of the process chemicals in use today can be effectively treated (112).

Tertiary Treatment

At the present time, tertiary treatment is not extensively done at many plant-owned facilities. The main reason probably is that conventional secondary treatment is all that is required by the state regulatory agencies for the discharge of effluents to stream in their states. Carbon adsorption has recently been introduced to the textile industry (8). Polishing logoons following secondary treatment are sometimes referred to as tertiary treatment.

Sludge Disposal

In most of the treatment methods described above, the process of waste water purification produces sludges or solid wastes that must be disposed of. Sludge from chemical coagulation can be dewatered, dried, buried, or used as land fill. These disposal methods may be used with sludge from biological processes or it may be further degraded in an anaerobic sludge digester (37).

Cotton Wastes

Figure 13 is a recommended waste treatment flow chart for the cotton textile finishing industry (33). The wastes from the individual processes should be discharged to an equalization basin or its equivalent. This step is considered a necessity because of the variability of the wastes, the need for biological processes to receive consistent effluents, and the restrictions imposed by the municipal authorities. From equalization and holding, the effluents may be discharged to the treatment facility, be it municipal, plant-owned and treating only textile wastes, or plant-owned and treating combined wastes.

In-Plant Measures

For cotton processing, a mill that effectively employs in-plant measures may reduce by as much as 70 percent the total BOD load expected to be produced if these measures are not taken (32).

The BOD load of desizing can be reduced by 40 to 90 percent depending on the degree of sizing process chemical substitution (32). If a low BOD synthetic size replaces starch or gelatin completely, a 33 1/3 percent total mill BOD load reduction can be achieved (139). Table XVII lists the six most commonly used sizing compounds and their BOD values in parts per million and pounds per 1000 pounds of cloth.

The two most widely used synthetic sizing compounds are polyvinyl alcohol and carboxymethyl cellulose (140). If these two starch substitutes are used to replace starch in printing pastes, a 5 to 20 percent reduction of the mill's total BOD could be attained depending on the volume of goods printed (139). Before low BOD chemicals are used to replace high BOD chemicals consideration must be given to the effects the new chemicals will have on the waste treatment plant and receiving stream.

The reuse of weak dye rinses, the storage and reuse of dye and mercerizing baths, and counterflow washing can reduce the water consumption in cotton processing by 30 to 40 percent (139).

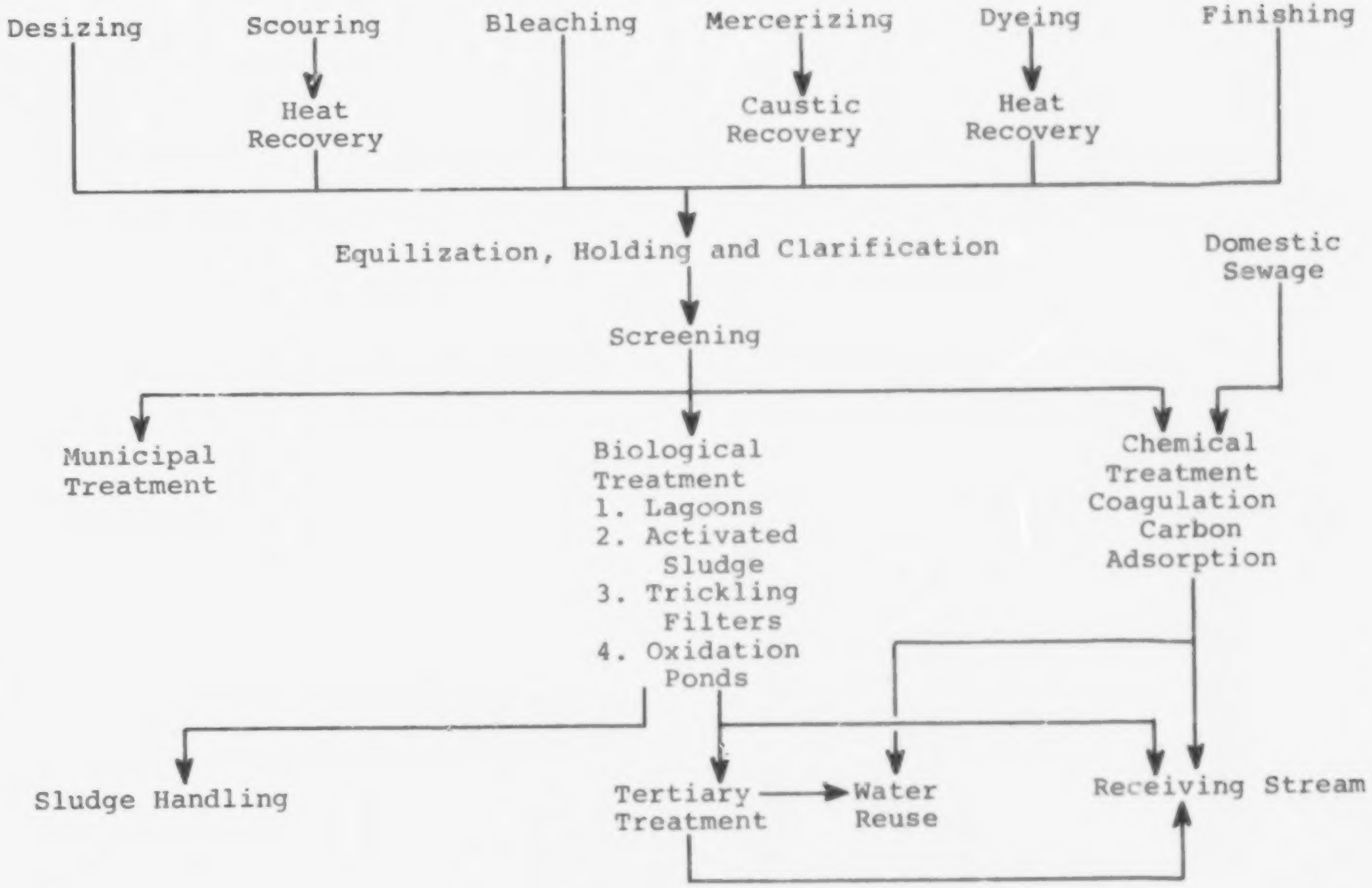
Desizing
Scouring
Bleaching
Mercerizing
Dyeing
Finishing
Heat Recovery
Caustic Recovery
Heat Recovery
Equilization, Holding and Clarification
Domestic Sewage
Screening
Municipal Treatment
Biological Treatment
1. Lagoons
2. Activated Sludge
3. Trickling Filters
4. Oxidation Ponds
Chemical Treatment Coagulation Carbon Adsorption
Sludge Handling
Tertiary Treatment
Water Reuse
Receiving Stream

Figure 13. Cotton Waste Processing Flow Chart.

TABLE XVII

BIOCHEMICAL OXYGEN DEMAND OF COMMONLY USED SIZING COMPOUNDS

Compound	BOD	
	p.p.m.	lbs./1000 lbs. of cloth
Corn Starch	810,000	477.0
British Gum	690,000	690.0
Methylcellulose	1,600	1.6
Carboxymethol-cellulose	10,000	9.0
Polyvinyl Alcohol	1,600	1.6
Polystyrene	12,000	1.2

Source: (Ref. 30, p. 550; Ref. 68, p. 920; Ref. 114, p. 171).

Treatment Efficiencies

In 1967, approximately 35 percent of cotton effluents were discharged to municipal sewers; this figure is expected to reach 40 percent by 1972 (33). The prolonged aeration form of the activated sludge process (141), a two stage activated sludge process, a two stage trickling filter process (142), and a high rate trickling filter followed by an activated sludge process (36) have all been used with combinations of domestic sewage and textile wastes to reduce BOD over 90 percent. Table XVIII lists the removal efficiencies of various treatment processes used on cotton water wastes.

The values in Table XVIII reflect the use of any auxiliary units normally associated with the process; for example, the trickling filter and activated sludge efficiencies cited required primary sedimentation and effluent circulation (33).

The activated sludge process with extended aeration times and a higher concentration of mixed liquor suspended solids than produced by the conventional method, consistently produces BOD reductions of 90 percent or better (33). The single-stage trickling filter process cannot reach the removal efficiencies of conventional activated sludge and is therefore expected to be used less in the future.

Polishing ponds have been used in treating cotton wastes. The most economical method is to simply store the treated effluent in an oxidation pond after it has been subjected to secondary treatment. Polishing ponds may reduce the effluent's pollutional load an extra 50 percent; for example, from 90 to 95 percent total BOD removed (33).

TABLE XVIII

TREATMENT REMOVAL EFFICIENCIES
REMOVAL EFFICIENCY (PERCENT)

Removal Method	BOD	Suspended Solids	Total Dissolved Solids
Screening	0-15	5-20	0
Sedimentation	5-15	15-60	0
Chemical Coagulation	25-60	30-90	0-50
Trickling Filter	40-85	80-90	0-30
Activated Sludge	70-95	85-90	0-40
Lagoon	30-80	30-80	0-40
Aerated Lagoon	50-95	50-95	0-40

Source: (Ref. 33, p. 66).

Wool Wastes

Figure 14 is a representation of the waste treatment flow chart for wool processing wastes. The only effluents in wool processing that would require segregation are the wool scour liquors, which produce 30 percent of the mill's total BOD (143). Two reasons for segregating wool scouring liquors are to reduce the high organic load on secondary biological treatment facilities or to recover wool grease, which is a major source of high quality lanolin (144). However, wool scour liquors can be discharged to equalization basins along with the three other wool waste producing processes.

There are three methods of degreasing wool scour liquors: acid or salt cracking, centrifuging, and solvent extraction. Centrifuging may be used by itself to recover 25 to 40 percent of the grease from the scour liquor or may be used on high grease content liquors as a pretreatment step for salt or acid cracking (116). In the acid cracking process sulfuric acid is added to settled scour liquor and the mixture is aerated, allowed to stand overnight, and the resultant "magna" is either scooped off the surface or passed through the sludge disposal drain. This process is used on scour liquors containing synthetic detergents. It removes about 65 percent of the grease from the effluent (116). The salt cracking process makes use of calcium chloride addition to soap and alkali scour liquors. At present the wool grease, soap, and alkali are precipitated as an emulsion from the liquor, thus making recovery of wool grease by this method uneconomical (145). Solvent degreasing uses

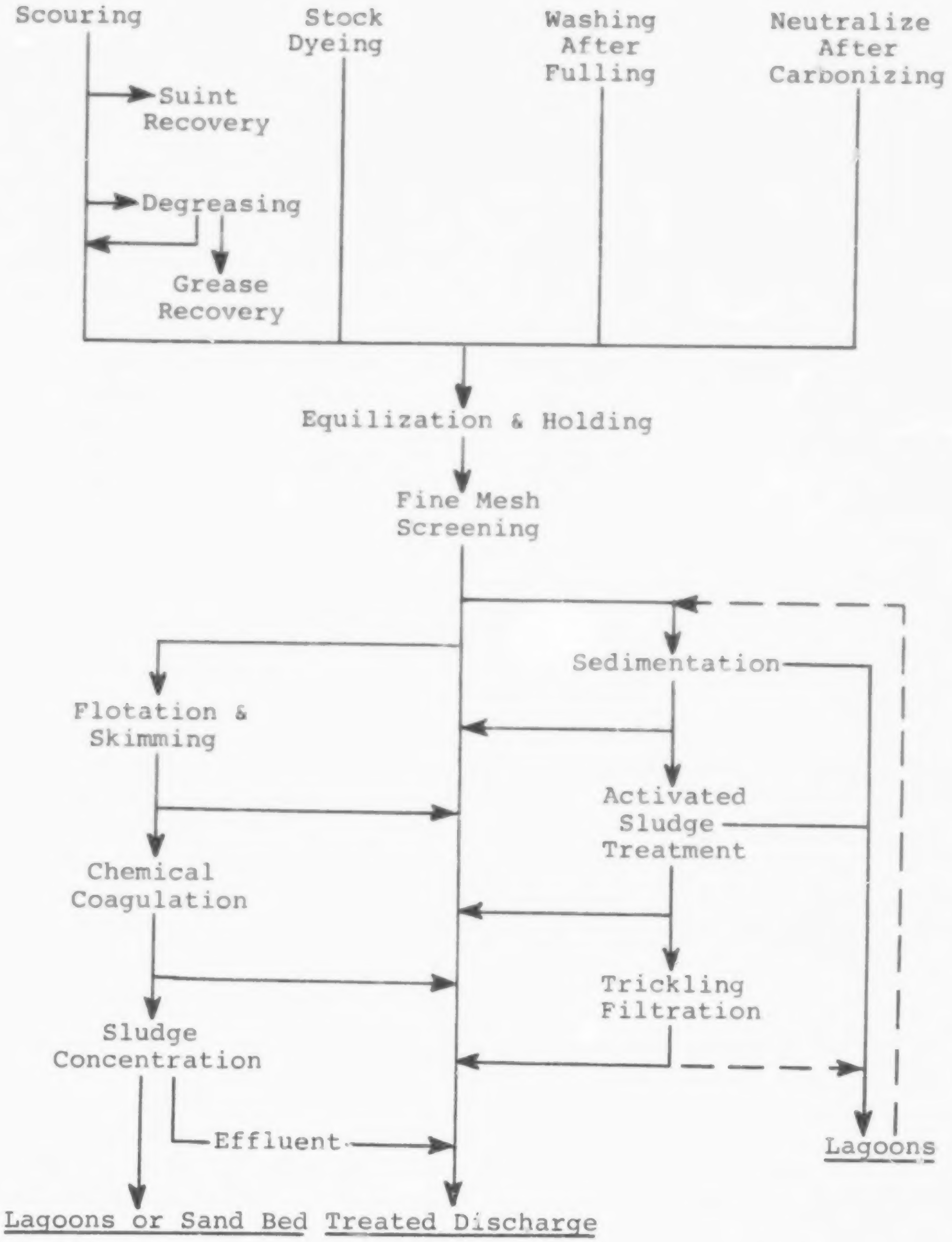
Scouring
Stock Dyeing
Washing After Fulling
Neutralize After Carbonizing
Suint Recovery
Degreasing
Grease Recovery
Equilization & Holding
Fine Mesh Screening
Sedimentation
Flotation & Skimming
Activated Sludge Treatment
Chemical Coagulation
Trickling Filtration
Sludge Concentration
Effluent
Lagoons
Lagoons or Sand Bed
Treated Discharge

Figure 14 Wool Waste Processing Flow Chart.

two separate alcohol extraction procedures. Methanol is used to remove suet salts from the fibers and ethanol or a mixture of isopropanol and methanol is used for removal of grease. The grease is then recovered by evaporation (32). However, this process does not remove the inert vegetable matter contained in raw wool fiber (45). Suet recovery is not often practiced, although total plant BOD reductions of 45-50 percent are possible if both suet and grease are removed from the scour liquors (32).

Because most wool processing mills are located adjacent to or within population centers, such as the New England and Middle Atlantic Regions of the United States, it has been traditional for them to dispose of their waste to municipal sewers. It has been estimated that 60 percent of the effluents from wool manufacturing were discharged to municipal sewers in 1967. By 1980 it is expected that 80 percent of the woolen mills in the country will use municipal treatment (33).

Equalization of wool process effluents, whether discharged to municipal or plant owned facilities, is a necessity as most of the processes are batch operations. Wool also has a high settleable solids content, composed mostly of grease, inert dirt, and small fibers. These solids should be removed as efficiently as possible in order to assure proper functioning of chemical and biological oxidation processes (136).

In the past, wool wastes were treated at plant owned facilities by chemical precipitation with grease recovery. Today, the activated sludge process using extended aeration and pH adjustment will reduce BOD load about 90 percent (33).

Table XIX lists the pollution reduction percentages of the various treatment techniques used for wool wastes. The figures cited for activated sludge, trickling filter, and lagoons are for systems that make use of degreasing either by recovery or chemical coagulation prior to treatment.

Synthetic Wastes

Figure 15 is a waste treatment flow chart for synthetic fiber finishing wastes. These are free from fiber impurities except for the small amount of nylon which is decomposed during the scouring of that fiber (32); therefore, any waste reduction program must deal with reducing the BOD load of the process chemicals. The substitution of low BOD process chemicals for ones with high BOD values can reduce the total BOD load of a mill by 35 percent (51).

In general, the wastes produced by synthetic fiber wet processing have a lower pollution potential than those of natural fiber effluents. The greatest pollutional load in synthetic fiber processing is generated by the dyeing of polyester and acrylic fibers. The problem is associated with the special dyeing assistants used with these two fibers. These "carriers" give rise to three sources of pollution: odor, toxicity, and high BOD (33).

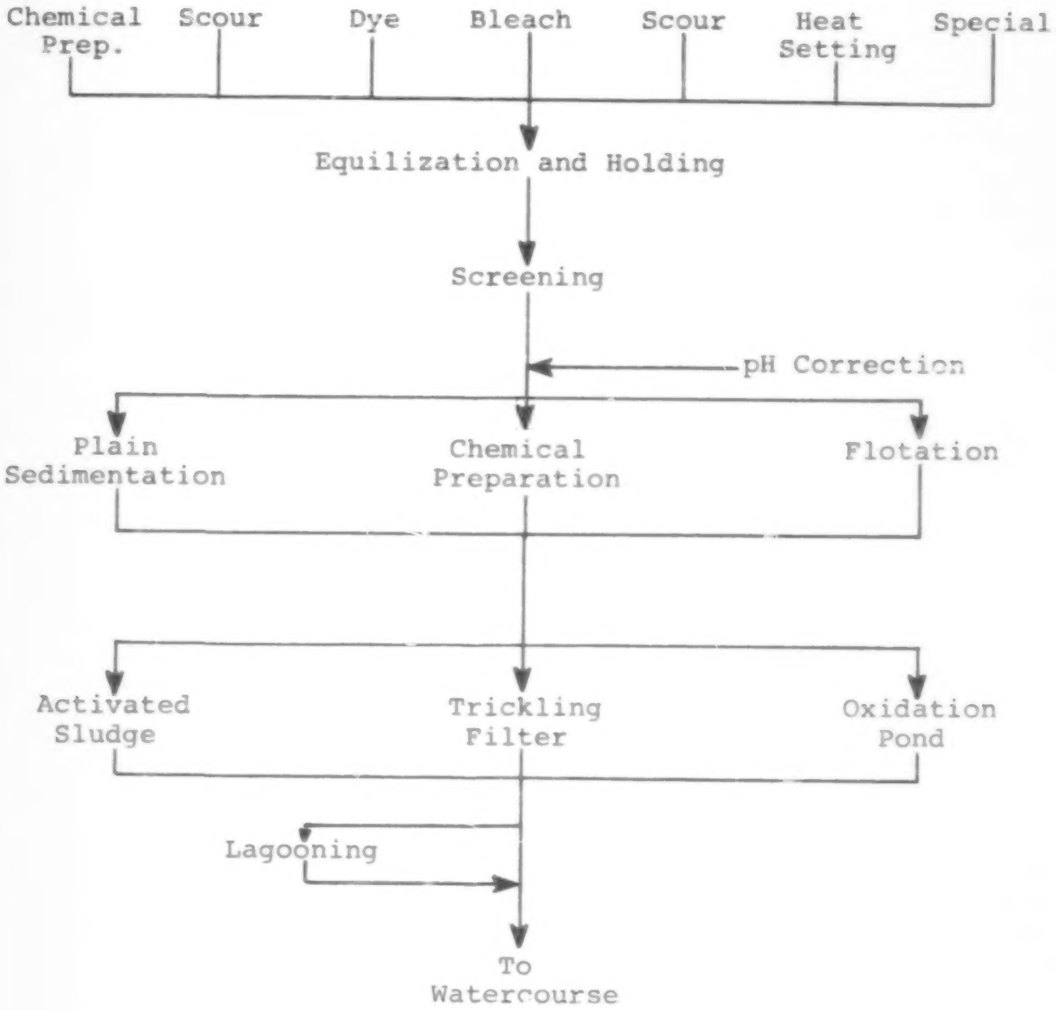
Chemical Prep.
Scour
Dye
Bleach
Scour
Heat Setting
Special
Equilization and Holding
Screening
pH Correction
Plain Sedimentation
Chemical Preparation
Flotation
Activated Sludge
Trickling Filter
Oxidation Pond
Lagooning
To Watercourse

Figure 15 Synthetic Textile Finishing Waste Treatment Flow Chart.

TABLE XIX

REMOVAL EFFICIENCIES OF TECHNIQUES USED IN WOOL WASTE TREATMENT

Treatment Method	Removal BOD	Efficiency Grease	Suspended Solids (Percentage)
Grease Recovery:			
Acid Cracking	20-30	40-50	0-50
Centrifuge	20-30	25-45	40-50
Evaporation	95	95	
Screening	0-10	0	20
Sedimentation	30-50	80-90	50-65
Flotation	30-50	95-98	50-65
Chemical Coagulation:			
Ca Cl_2	40-70		80-95
Lime and Ca Cl_2	60	97	80-95
CO_2- $CaCl_2$	15-25		80-95
Alum	2[illegible]-56		
Copperas	20		
H_2SO_4 and Alum	21-83		
Urea and Alum	32-65		
H_2SO_4 and $FeCl_2$	59-84		
Fe SO_4	50-80		
Activated Sludge	85-90	0-15	90-95
Trickling Filter	80-85	0-10	90-95
Lagoons	0-85	0-10	30-70

Source: (Ref. 33, p. 26).

Table XX outlines the relative BOD load reduction potentials of various process modifications used in treating synthetic fiber wastes.

In order to realize these potential BOD reductions, the following sequential procedure must be employed. First, scouring must precede or be concurrent with dyeing or bleaching; final scouring or the salt bath must follow dyeing, and special finishing if applied must follow all other processing (33).

Either biological oxidation or chemical precipitation can be the principal BOD reduction treatment for synthetic fiber processing mill wastes (32). Segregation or chemical pretreatment may be required to treat the toxic chemicals used in polyester and acylic dyeing before biological treatment.

In 1967, it was estimated that half of the total synthetic fiber processing effluents were discharged to municipal sewers. By 1972, it is estimated that 55 percent of these effluents will be discharged to municipal sewer systems (33).

It is common procedure in treating synthetic fiber wastes to adjust the pH of the waste stream prior to chemical coagulation in order to reduce the requirement of costly coagulation chemicals (33). As synthetic fiber processing wastes have low concentrations of suspended solids, sedimentation may be eliminated or replaced by fine screening (111).

TABLE XX

BIOCHEMICAL OXYGEN DEMAND REDUCTION POTENTIALS OF SYNTHETIC TEXTILE FIBER PROCESS MODIFICATIONS

Process	Fiber	BOD Reduction (percent)
Scour: Continuous Machines	Nylon, Acrylic and Polyester	10-15
Scour and Dye: Continuous Machines	Rayon and Acetate	10-15
Scour and Bleach: Continuous Machines	Rayon and Acetate	10-15
Dye:	Nylon, Acrylic	Depends on dye
Dye: High temperature pressure machine	Polyester	80
Bleach: Continuous Machines	Nylon, Acrylic Polyester	5-10
Final Scour: Continuous Machines	Acrylic and Polyester	10-20
Special Finishing	All fibers (optional)	Depends on finish

Source: (Ref. 33, p. 103).

Table XXI lists the BOD removal efficiencies of treatment processes used for synthetic fiber processing waters.

TABLE XXI

REMOVAL EFFICIENCIES OF TREATMENT METHODS USED FOR SYNTHETIC FIBER WET PROCESSING WASTES

Treatment Method	Removal of Efficiency (Percent)		
	BOD	S. S.	T.D.S.
Screening	0-5	5-20	0
Sedimentation	5-15	15-60	0
Chemical Precipitation	25-60	30-90	0-50
Trickling Filter	40-85	80-90	0-30
Activated Sludge	70-95	85-95	0-40
Lagoon	30-80	30-80	0-40
Aerated Lagoon	50-95	50-95	0-40

Source: (Ref. 33, p. 105).

Due to the fact that synthetic fiber processing wastes contain only the chemicals used in finishing, reuse of process chemicals would probably be practiced if economically feasible methods of recovery were developed.

Dyeing Wastes

Wastes from the dyeing of textile fibers present a particular problem to the industry. As mentioned previously, some dyestuffs, for example, sulphur dyes, are toxic in themselves, or, as in the case of polyester dyestuffs, require the use of toxic assistants, emulsifiers, and leveling agents. These chemicals, however, can be effectively treated by segregation or chemical coagulation. The real difficulty lies in the color imparted to receiving streams by dyestuff residues. Although most dyes have low BOD values they add organic carbon and color to the water which is objectionable to the public for aesthetic reasons (112, 145). In the late 1950's, research studies of color removal from textile effluent streams showed that the trickling filter and activated sludge processes could remove effectively 84 and 93 percent of the color in textile effluents (8), and chemical coagulation of cotton dye wastes averaged 80 to 91 percent removal of color (68). The color of today's new, improved and virtually non-destructible dyes can only be reduced by 50 to 85 percent (112). Therefore, if public authorities insist on clear water, improved methods of removing the residual organic dyestuffs from textile effluents must be developed. Methods that have been used include carbon absorption (8) and chemical coagulation (68). Another suggested method of reducing color from dyehouse wastes is to subject the wastes to sunlight (5). In the last case the time requirements would make the process unattractive for most dyes.

TREATMENT OF TEXTILE EFFLUENTS SUMMARY

Due to the variations inherent in textile water wastes, a survey should be made of all the mill's wet processes to determine as exactly as possible the composition and volume of its effluents. A simplified survey method which can be used for textile processing involves studying the production records, water consumption, and on-weight-of-fabric formulations to determine the amount of goods processed in each operation, the amount of process chemicals used in each operation, and the water consumption for the entire processing operation. With this data three simple calculations can be made to determine the BOD load in both pounds and parts per million and the concentration of each process chemical in the effluent. The information obtained in this survey will often be sufficient for treatment plant design, in the absence of a complete waste profile developed by long term sampling of all waste streams.

The BOD load of textile fiber processing wastes can be reduced significantly by in-plant measures: reduction of waste-water volume, reduction in process chemical use, reuse of process chemicals, process modifications, substitution of process chemicals, and good housekeeping. BOD loads have been reduced by as much as 75 percent in cotton processing, by 30 to 70 percent in wool, and up to 40 percent in synthetic wastes through successful implementation of these measures (112).

The treatment of textile wastes involves equalization, neutralization, removal of suspended solids, and oxidation of organic solids. The first two operations can be accomplished during the preliminary and primary treatment.

When possible, textile wastes may be discharged to municipal sewer systems. This procedure is more economical than the construction of plant owned facilities, and is sometimes more efficient in terms of pollution reduction than plant-owned facilities.

When in-plant treatment is required, physical and chemical methods and activated sludge systems have been found capable of reducing BOD loads to the limits required by state regulatory agencies. The extended aeration activated sludge process is the most often used biological system.

Chemical pretreatment, coagulation, or segregation must be performed on the wastes prior to secondary biological treatment if the wastes contain toxic materials. Wool wastes must be chemically pretreated or subject to a grease recovery operation prior to discharge to secondary treatment facilities.

COST OF TREATMENT PROCESSES

Biological Treatment

The cost of construction and operation is hard to estimate in our rapidly changing economy. However, some guide-lines must be established if we are to compare waste treatment methods. For biological treatment of textile waste we can look at some of the data reported by Farrow, Hirth and Judkins (146).

They reported on the construction cost for plants using each of the three methods of secondary treatment: trickling filters, activated sludge, and mechanically aerated lagoons. Waste water flowrates ranged from 250,000 to 6,000,000 gallons per day. At a given flowrate the plant construction cost was determined for three representative BOD concentrations: 300, 450 and 700 p.p.m.

The construction costs for the trickling filter and activated sludge treatment plants were developed with the aid of U. S. Public Health Service Publication No. 1229 (147). Although this report was based on domestic waste treatment facilities, factors such as population equivalent, waste volumes, overflow rates and organic loading were taken into consideration in adjusting the cost figures to conform to textile waste treatment practices.

Construction estimates for treatment using mechanically aerated lagoons are based on several recent confidential engineering studies for actual facilities handling 1.4 million gallons per day.

All of the construction cost data, based on a 1968 dollar, are shown in Figures 16 through 22. The costs include a factor of 20% for overhead, but exclude the cost of the necessary land.

Three different options are referred to in Figure 16-22. Option 1 is conventional process with tapered aeration and consist of a primary sedimentation tank, an aeration unit and a secondary sedimentation tank in series. Sludge is returned to the aeration unit from the secondary sedimentation tank to achieve the desired biological growth conditions. A six-hour retnetion time is typical for the aeration tank. Compressed air in decreasing amounts is introduced at various points along the length of the aeration unit. Option 2 replaces the primary sedimentation tank and sludge digestion with a three-day holding pond and sludge lagoons respectively. Option 3 replaces the primary sedimentation tank in Option 1 with a three-day holding pond.

Comparison of Costs

Mechanically aerated lagoons are considerably cheaper to construct than trickling filters or activated sludge units, regardless of flowrate or BOD concentration. It

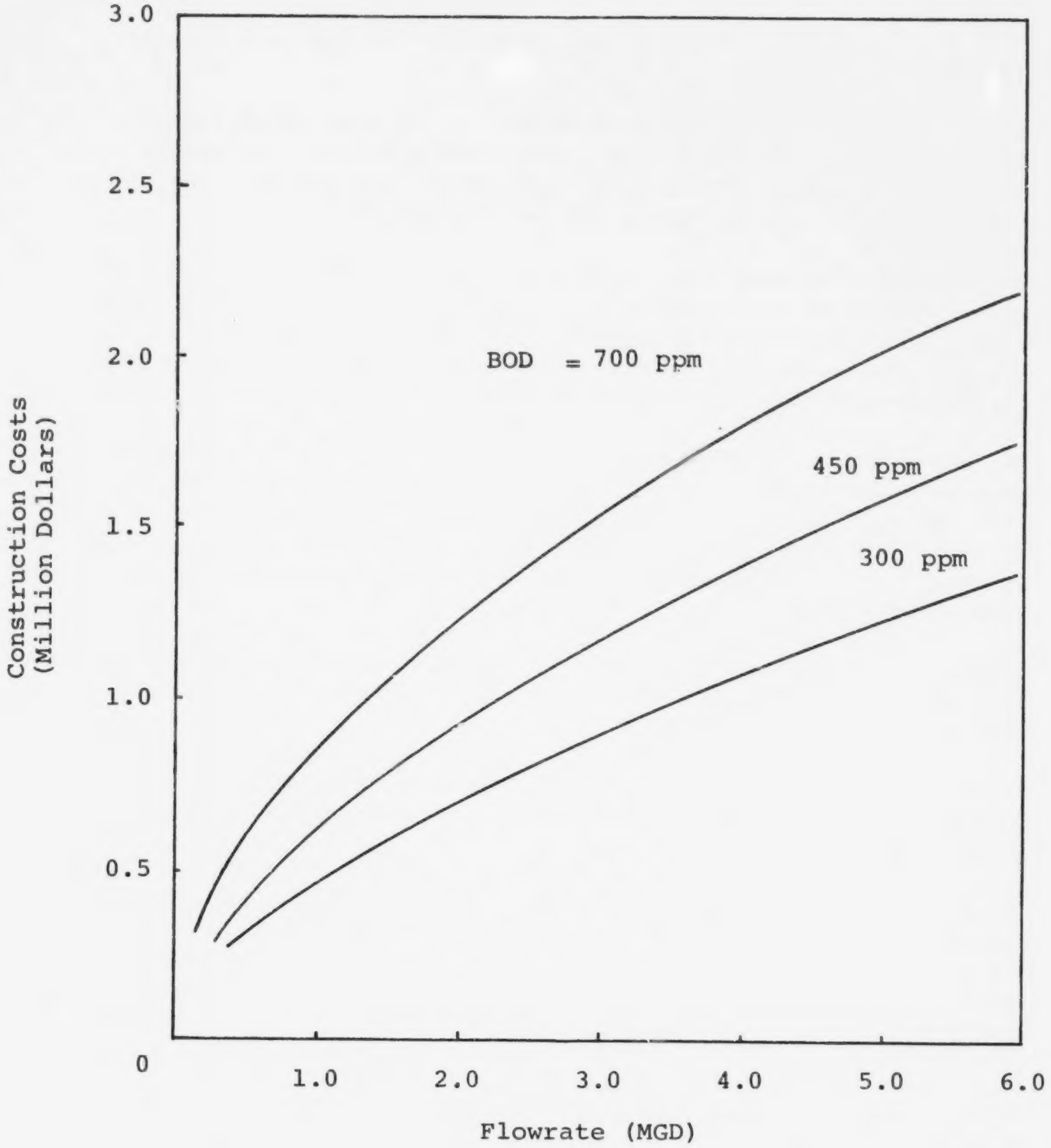

Figure 16. Trickling Filter (Option 1) Construction Costs (Ref. 146)

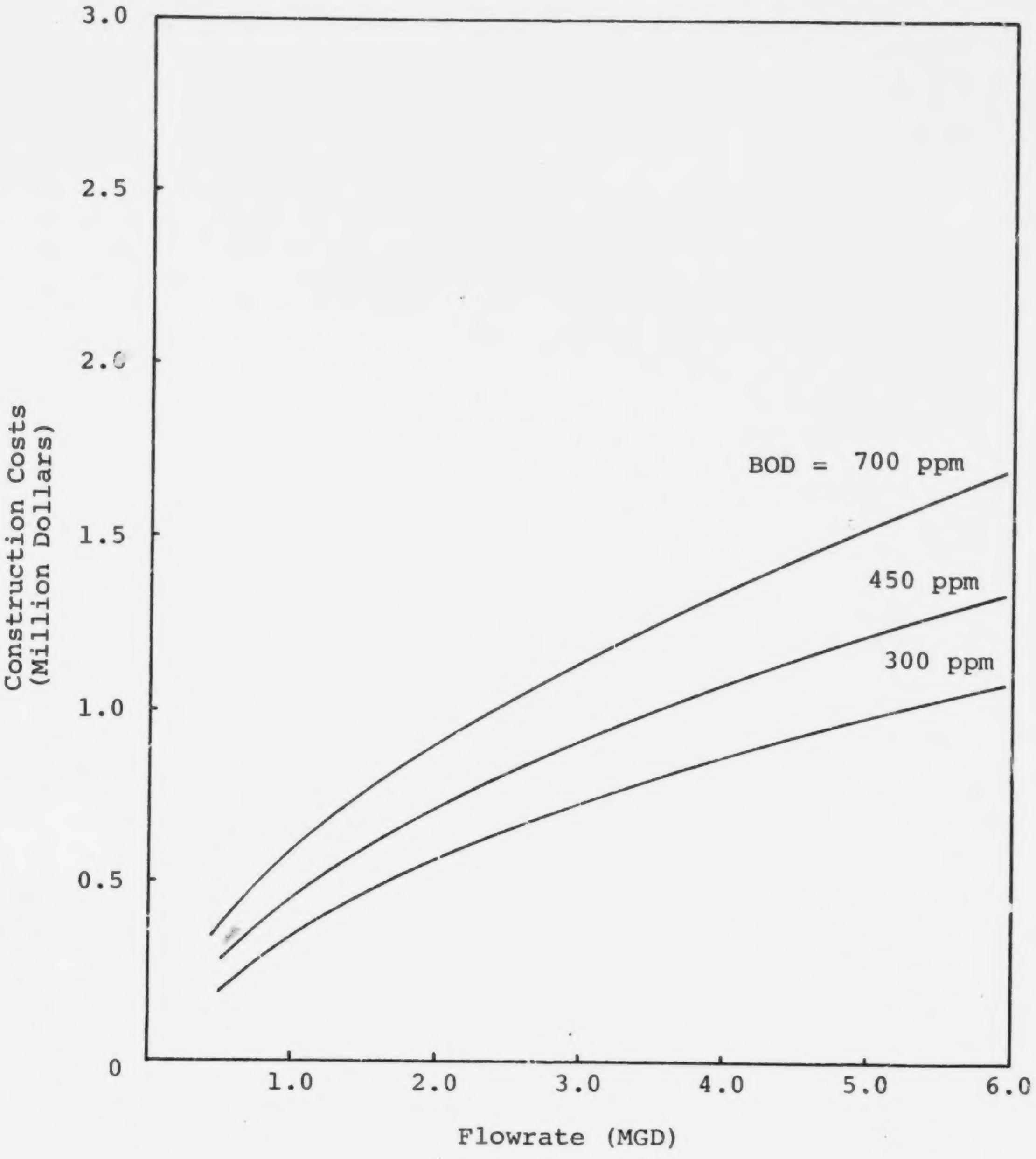

Figure 17. Trickling Filter (Option 2) Construction Costs (Ref. 146)

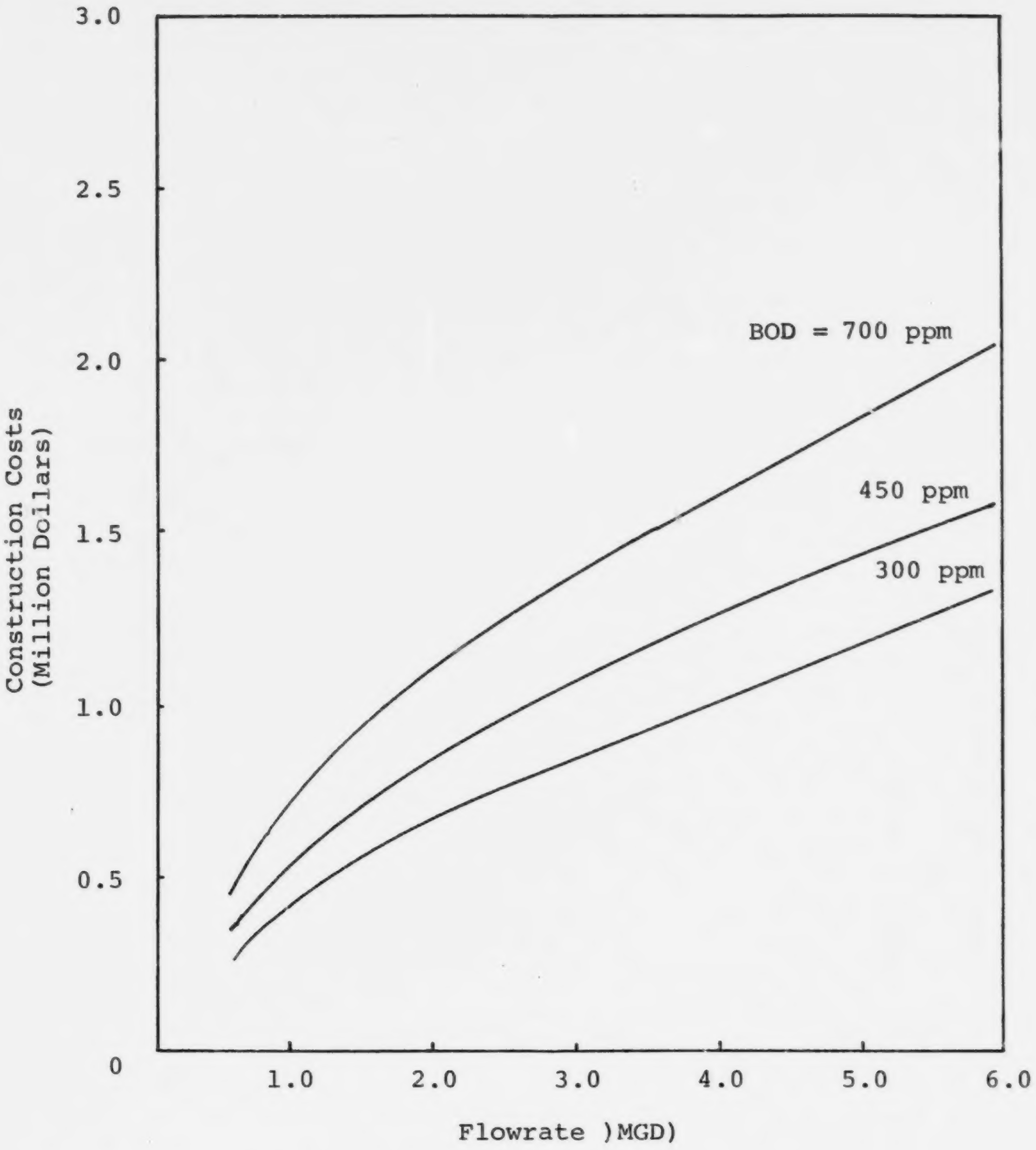

Figure 18. Trickling Filter (Option 3) Construction Costs (Ref. 146).

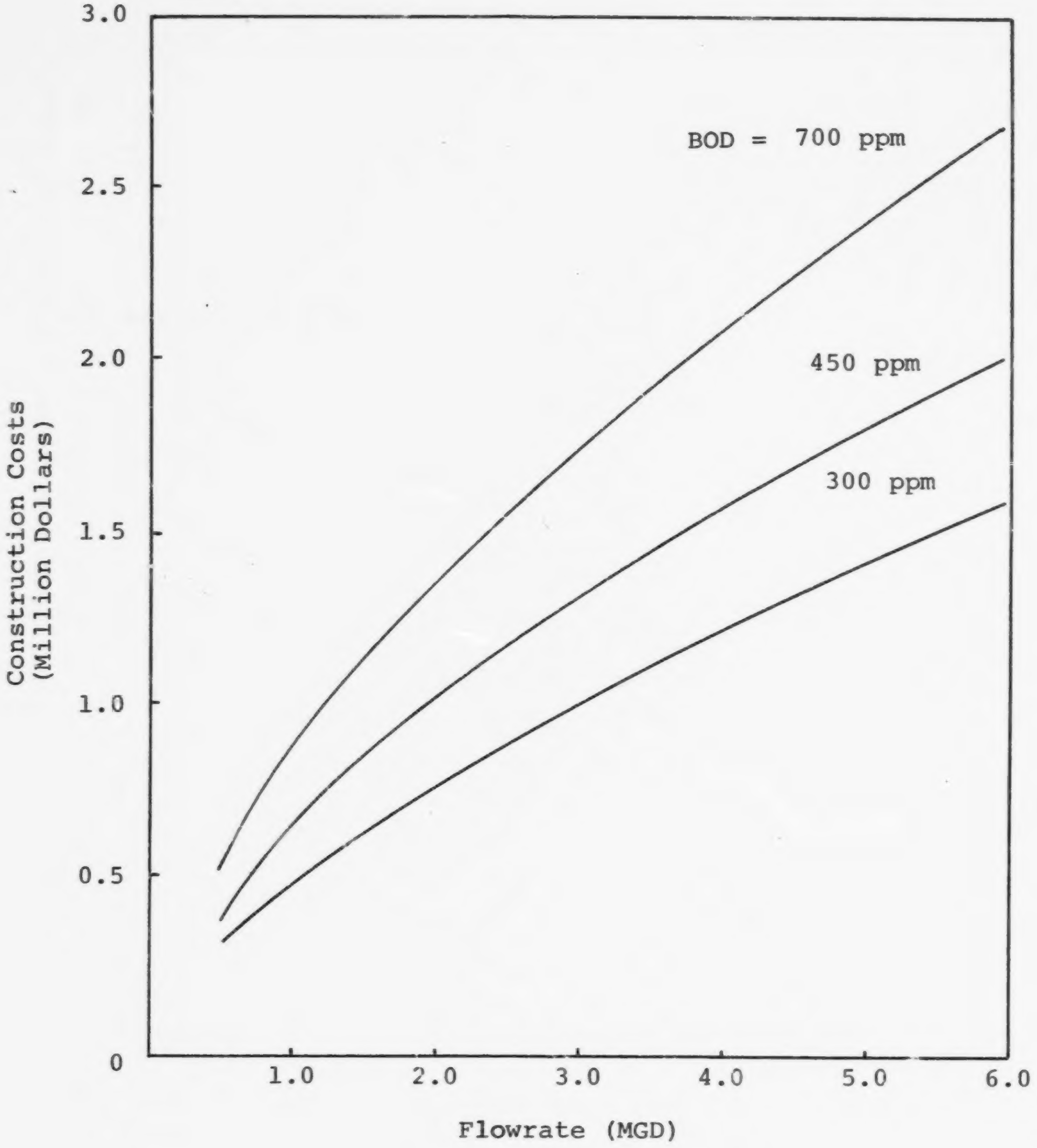

Figure 19. Activated Sludge (Option 1) Construction Costs (Ref. 146)

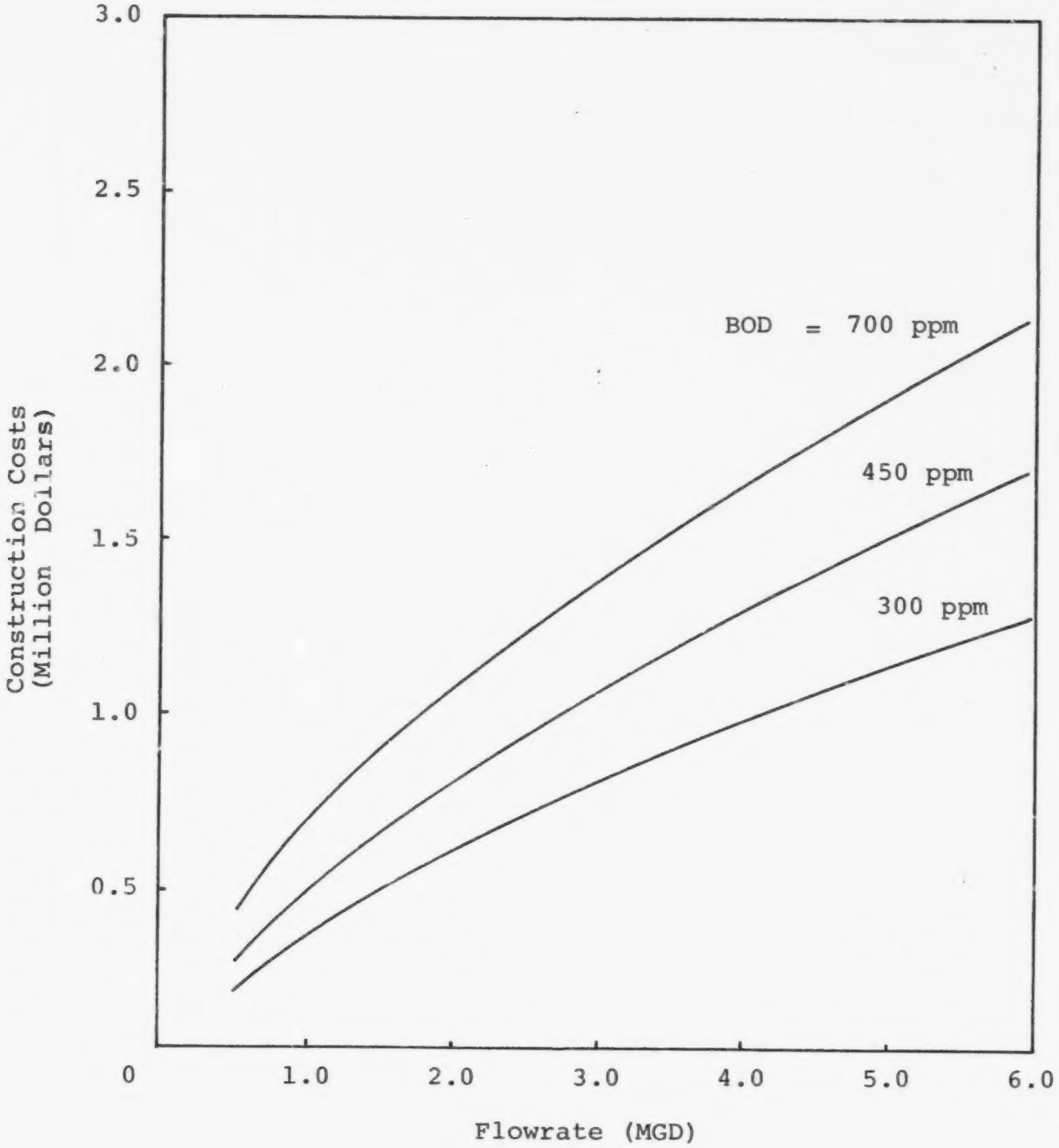

Figure 20. Activated Sludge (Option 2) Construction Costs (Ref. 146).

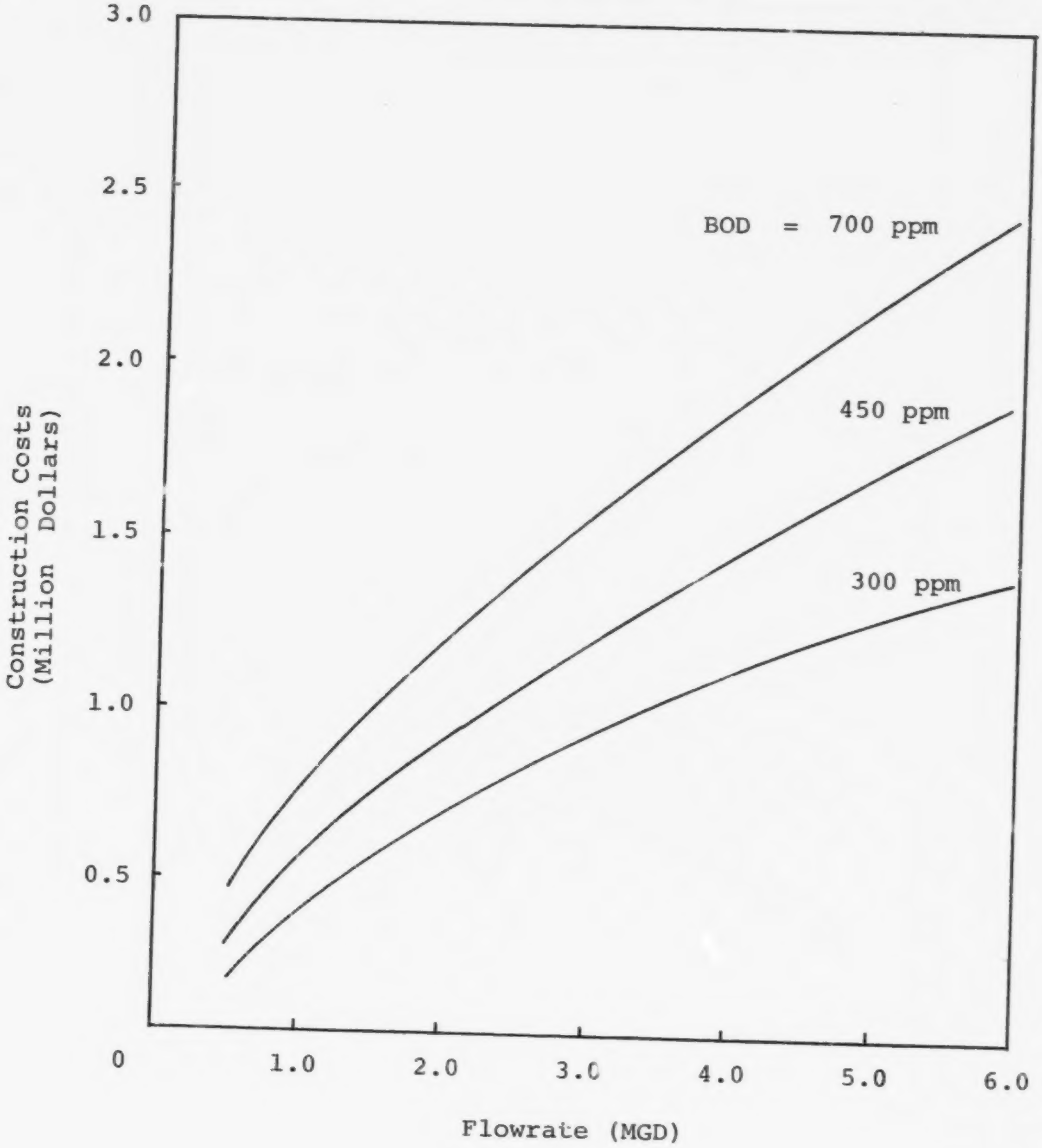

Figure 21. Activated Sludge (Option 3) Construction Costs (Ref. 146).

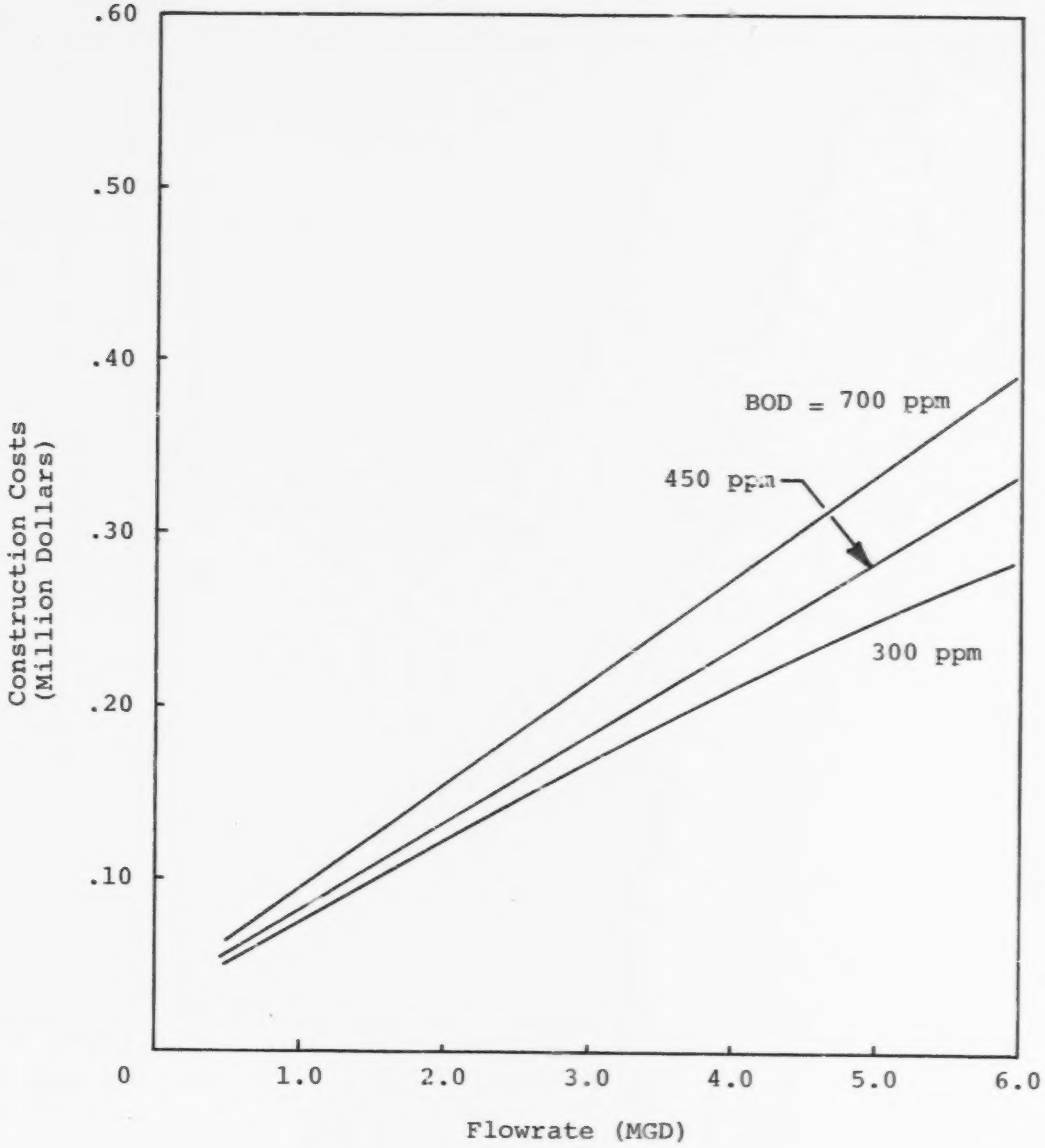

Figure 22. Aerated Lagoon Construction Costs (Ref. 146).

should be emphasized, however, that the selection of any treatment method should be based on treatability studies followed by a pilot plant study using the same waste at flowrates and BOD concentrations expected to be produced by the plant.

Textile plants in or near cities may choose to have their waste handled along with domestic sewage in the city treatment system. Such treatment systems usually employ either trickling filters or activated sludge units. Cooperating with a city has the advantage of reducing capital outlay, since cities can apply for federal funds to expand their sewage treatment facilities. The textile plant would then be billed by the city on the plant's proportional contribution in waste flowrate or BOD to the total treatment load.

The choice between activated sludge or trickling filters depends on the waste flowrate, operating cost, and the availability of qualified plant personnel. According to Public Health Service Publication No. 1229 (147), activated sludge construction is cheaper at flows below 750,000 gallons per day. But at higher capacities, the construction cost advantage favors trickling filters. Operating costs are usually higher for activated sludge plants than for trickling filters because of aeration expenses and additional pumping costs. Although activated sludge units may yield slightly higher BOD reductions than trickling filters, the process is quite sensitive to shock loads, and operational problems are not uncommon. Any biological process needs biodegradable chemicals for food and protection from toxic chemicals and shock loading. The best method for waste treatment will depend on the available space and the particular waste stream in addition to the construction cost.

Chemical Treatment

The data for cost estimation of chemical treatment of textile waste is very limited as this treatment method has not been used except in rare cases. We do know that water prepared by chemical means for plant use costs anywhere from five to twenty cents per 1,000 gallons depending on the quality of the source water available. No doubt this rising cost and the ungrading of effluent standards will make chemical treatment for water reuse much more attractive. A Summary Report on Advanced Waste Treatment (148) gives a cost estimation of five to eight cents per 1,000 gallons of water treated for alum, lime, and polyelectrolyte chemicals. This seems like a low estimate, but even if the cost is higher it is worth consideration.

More data has been published on carbon absorption, and we have previously referred to its use in one textile plant. To provide a more general idea of carbon adsorption cost the following Table XXII and Figure 23 are presented. This data was prepared by M. W. Kellogg Company for the Robert A. Taft Water Research Center using a municipal waste stream having a total COD of 60 mg./l. influent and 9.5 mg./l. effluent. This data is not taken from a textile waste stream, but the reader should get a better feel for the cost of this type treatment from the data shown. For more information the following references are given (4,8,92).

TABLE XXII

ECONOMICS OF CARBON ADSORPTION FOR MUNICIPAL WASTES

Plant Size	1 MGD	10 MGD	100 MGD
Contactor Type	Downflow	Downflow	Downflow
Velocity, GPM/ft^2	7	7	7
Contact Time, Min.	50	50	50
Carbon Particle Size, Mesh	8 × 30	8 × 30	8 × 30
Regeneration Loss, %	5	5	5
Carbon Capacity, lb. COD/lb C	0.522	0.522	0.522
Vessel Size	11'6" I.D. × 30'	25'6" I.D. × 30'	25'6" I.D. × 30'
Number of Vessels	4	6	44
Number of Trains	1	2	20
Investment, $M			
Concrete	29	121	811
Absorbers	74	253	1765
Tanks	2	5	12
Pumps	17	98	433
Special Equipment	27	36	150
Piping	43	158	1599
Conveyors	2	4	23
Total Major Material	194	675	4793
Plant Investment	331	1210	8060
Carbon @ 26¢/lb.	48	390	3276
Fixed-Capital Investment	379	1600	11,736

TABLE XXII - Continued

Operating Costs, ¢/M Gal.			
Make-up Carbon @ 26¢/lb.	1.09	1.09	1.09
Power @ 1¢/kwh	1.21	1.00	0.79
Backwash Water	0.47(1)	0.31(2)	0.18(3)
Fuel Gas @ 25¢/MM Btu	0.15	0.15	0.09
Labor @ $3.50/Man-Hr.	8.40	1.05	0.25
Overhead @ 50% Labor + 1.485% PI/Yr.	5.55	1.02	0.45
Amortization @ 7.4% FCI/Yr.	7.58	3.24	2.38
Maintenance @ 5.75% PI/Yr.	5.21	1.91	1.27
Insurance @ 1% FCI/Yr.	1.04	0.44	0.32
Total Operating Cost	30.80	10.21	6.82

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(1) Backwash Water (Secondary Effluent) @ 9¢/M gal.
(2) Backwash water (secondary effluent) @ 6¢/M gal.
(3) Backwash water (secondary effluent) @ 3¢/M gal.

Source: (Ref. 4 p. 64).

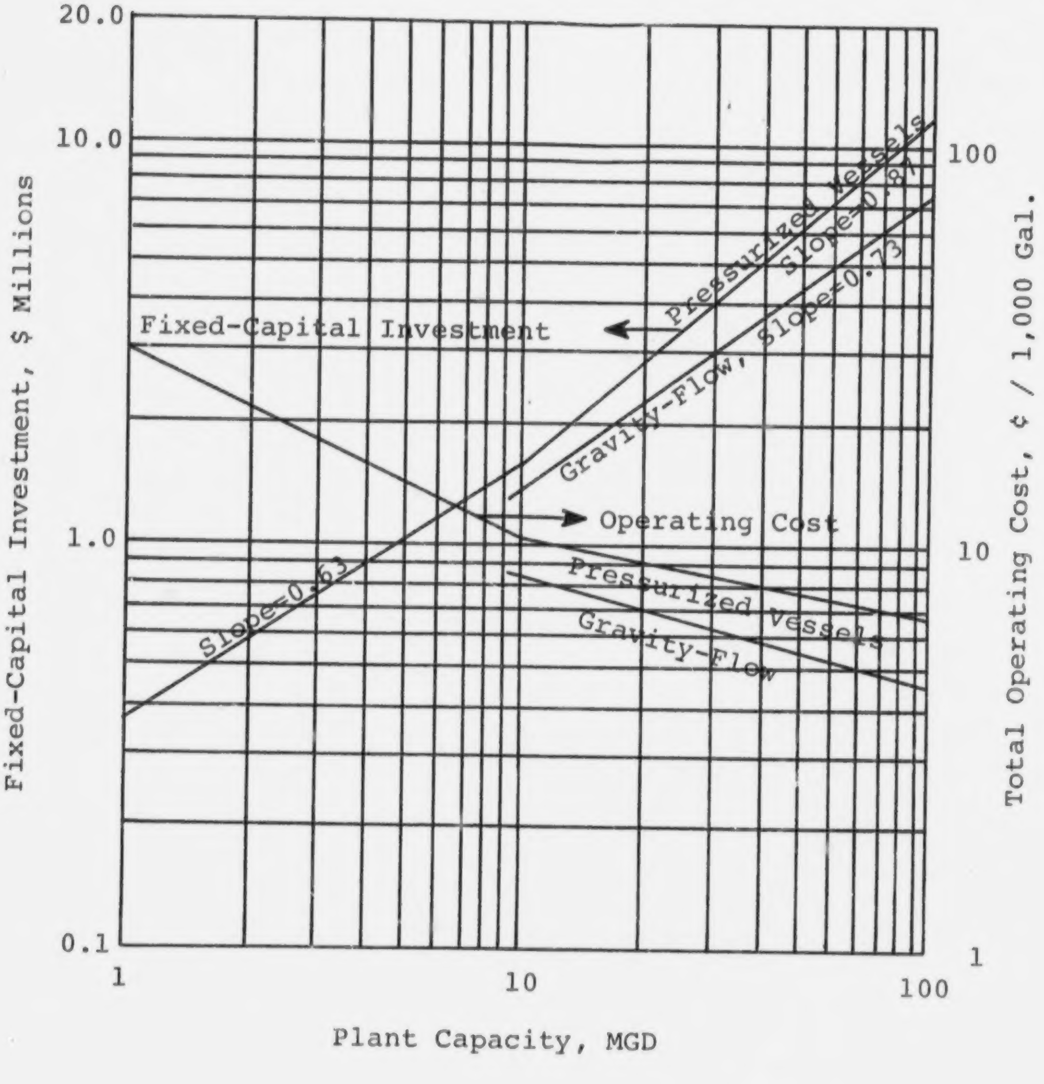

Figure 23. Costs as a Function of Plant Size - Tertiary Waste Water Treatment - Granular Activated Carbon Municipal Waste (Ref. 4)

If increased use of chemical methods for waste treatment lowers their cost, they could have several advantages over their sensitive biological counterparts. Anyone who is paying the price for installation of a waste treatment plant would do well to look at chemical methods and water reuse.

ACKNOWLEDGEMENTS

The investigators would like to express their appreciation to several people who have made contributions to this report.

Several textile mills were visited and were very cooperative in offering data and suggestions for needed improvements in textile waste treatments. Without their help the report would have less value.

Over 17 state agencies concerned with the regulations affecting textile waste water treatment were also visited. They offered many helpful suggestions for treatment improvements. Information obtained from them is included in the report.

Many engineering firms that design waste treatment plants offered their suggestions for research that would improve textile waste treatment.

A list of agencies and plants visited is included in Appendix C.

Finally, appreciation is expressed for the cooperation and financial support of the Industrial Pollution Control Branch of the Federal Water Quality Administration.

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STATE OF THE ART OF
TEXTILE WASTE TREATMENT

APPENDIX

A STUDY CONDUCTED FOR
WATER QUALITY OFFICE
ENVIRONMENTAL PROTECTION AGENCY

APPENDIX A

WATER POLLUTION CONTROL LEGISLATION

Introduction

Individual states have always had the right to control and prevent pollution of waters within their boundaries. The Federal Government limits its involvement to pollution of coastal, interstate, and international waters. Even in these areas it gets involved only when the states request assistance or fail to handle the problems themselves.

For this paper, only the laws of the twelve states in which a major portion of textile waste producers are located shall be studied. These twelve are: Connecticut, Massachusetts, Rhode Island, New Jersey, New York, Pennsylvania, Alabama, Georgia, North Carolina, South Carolina, Tennessee and Virginia. The pollution control laws, water quality standards, degree of treatment required, and the penalties for violation of the laws will be presented.

Federal Legislation

In 1948, the Congress of the United States passed the "Water Pollution Control Act" (A1). This legislation marked the Federal Government's first serious involvement in water pollution control. Two previous legislative acts, "The Rivers and Harbors Act of 1899" and "The Oil Pollution Act of 1924" concerned only the pollution of coastal and navigable waters.

The original version of the 1948 Act has been revised and amended over the past twelve years. The original Act was intended to exist for five years. In 1956, the Act, extensively revised, became known as "The Federal Water Pollution Control Act (33 United States Code 466)" (A2). It was further amended in 1961 (A3), in 1965 by the "Water Quality Act (A4), and again in 1966 by the "Clean Water Restoration Act" (A5). Another 1966 amendment (A6) transferred the duties, functions and authority of the Act from the Department of Health, Education and Welfare to the Department of the Interior. These duties were again transferred on December 2, 1970, to the Environmental Protection Agency.

The purpose of the legislation has been "to enhance the quality and value of our water resources and to establish a national policy for the prevention, control and abatement of water pollution" (A4). In entering the field of pollution control, the Congress has declared as its policy:

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> to recognize, preserve, and protect the primary responsibilities and rights of the States in preventing and controlling water pollution, to support and aid technical research relating to the prevention and control of water pollution, and to provide Federal technical services and financial aid to State and Interstate agencies and to municipalities in connection with the prevention and control of water pollution. (A2)

The Act has established two Federal agencies that are to be concerned with water pollution prevention and control. The 1956 amendments created the Federal Water Pollution Control Advisory Board composed of ten members, including the Secretary of the Interior, or his designee, who shall act as chairman. The Board "shall advise, consult with and make recommendations to the Secretary on matters of policy relating to the activities and functions of the Secretary under this Act". (A2) The other Federal agency was created by the "Water Quality Act" in 1965. This agency, formerly known as the Federal Water Pollution Control Administration, under the authority of the Secretary of the Interior is now the Water Quality Office of the Environmental Protection Agency.

Section 3 of this Act provides for joint investigations by the Federal Water Pollution Control Administration, State water pollution control agencies, interstate agencies, municipalities and industries to prepare or develop comprehensive programs for eliminating or reducing the pollution of, and improving the sanitary condition of interstate waters. This section also allows for the payment of a grant not to exceed fifty percent of the administrative expenses of a planning agency for a period of less than three years, if the planning agency provides for adequate representation of the State, interstate or local interests and provides an effective, comprehensive water quality control and pollution abatement plan for the area.

Section 4 of the Act encourages: cooperative activities by the States for the prevention and control of water pollution; the enactment of uniform State laws relating to water pollution prevention and control; and compacts between States for the prevention and control of water pollution.

The Secretary of the Interior, through Section 5, is to conduct, through the Federal Water Pollution Control Administration and in cooperation with public and private agencies and institutions, research, investigations, experiments, demonstrations, and studies relating to the causes, control and prevention of water pollution. The Secretary shall also collect and make available through publications the results and other information of such research, investigations, experiments, demonstrations and studies; make grants-in-aid to public or private agencies for such research, investigations, experiments, demonstrations and studies. This Section of the Act also gives him the authority to conduct investigations, research and surveys concerning any specific problem of water pollution confronting any State, interstate agency, community, or industrial plant, if requested to do so by the State water pollution control agency.

Section 6 of the Act provides for a Federal grant-in-aids for the research, studies, demonstrations and experiments mentioned in Section 5. These grants-in-aid are of two types. The first are those available to any State, interstate, municipal or intermunicipal agency for the purpose of assisting in the development of any project which will demonstrate:

> a new or improved method of controlling the discharge into any waters of untreated or inadequately treated sewage or other wastes from sewers or an advanced waste treatment and water purification methods (including the temporary use of new or improved chemical additives which provide substantial immediate improvement to existing treatment processes) or new or improved methods of joint treatment systems for municipal and industrial wastes. (A5)

The other type is a grant to persons for research for the prevention of pollution of waters by industrial waste treatment. The grant to public agencies cannot exceed seventy-five percent of the estimated cost, while the industrial grants cannot exceed seventy percent of the estimated cost or one million dollars, whichever amount is smaller.

Both type grants are subject to the Secretary of the Interior's determination that the project will serve a useful purpose in the development or demonstration of a new or improved method of treating wastes or preventing pollution (A5).

The Secretary of the Interior is empowered, through Sections 7 and 8, to grant Federal funds to State, interstate, municipal or intermunicipal agencies. The Section 7 grants-in-aid are to assist these public agencies in establishing and maintaining adequate measures for the prevention and control of water pollution. In order to receive these funds, the agencies must submit a plan for the prevention and control of water pollution in the particular drainage area and this plan must meet with the Secretary's approval. In Section 8, the Secretary is authorized to grant Federal funds to public agencies for the construction or alteration of water waste treatment and disposal facilities; provided that such facilities are approved by the State water pollution control agency.

Section 10 of the Act requires the establishment of water quality criteria for all the streams in the country and it sets forth the procedure involved in bringing the Federal Government into pollution abatement litigation. Subsection "c" of this section, which was incorporated into the Federal Water Pollution Control Act by the "Water Quality Act", deals with the setting of water quality criteria for all interstate and navigable waters. The Act specifies that these criteria "shall take into consideration their use and value for public water supplies, propagation of fish and wildlife, recreational purposes and agricultural, industrial and other legitimate uses" (A4). The States were given until June 30, 1967 to file a letter of intent with the Federal Water Pollution Control Administration which contained a list of water quality criteria applicable to the waters of the State and a plan for the implementation and enforcement of these water quality standards. If approved, these standards and the plan for their enforcement would become the recognized standards for the waters of the State. The Federal Water Pollution Control Administration had turned down some States' plans, but encouraged those whose standards were rejected to resubmit plans of their own. This subsection gives the Secretary of the Interior the right to promulgate standards of water quality for any State which fails to do so, within a reasonable period of time, after holding a public meeting with the water pollution control agency of the States concerned and the Federal Water Pollution Control Administration (A4). Virginia is the only "Textile State" which still has not submitted standards acceptable to the Federal Water Pollution Control Administration, but its Water Control Board is in the process of resubmitting new standards (A7).

Subsections "d" through "k" set forth the procedures required for the Secretary of the Interior to follow in order to seek the abatement of pollution. If the Secretary receives a report, survey or study that leads him to believe that any interstate or navigable waters are being polluted, by the discharge of untreated or improperly treated effluents, which endangers the health or welfare of any persons; or if he is requested by the Governor, State water pollution control agency, governing body of a municipality or the Secretary of State (in the case of pollution of international water) to help abate a source of pollution, he is to proceed in the following manner. In the case of a discharge that endangers the health or welfare of any persons in a foreign country, the Secretary shall give formal notification to the State water pollution control agency of the State in which the discharge originates to secure immediate abatement of the discharge; and he shall call for a conference between the appropriate foreign water pollution control agency, State water pollution control agency and the alleged polluter in order to secure permanent abatement of such pollution (A5). In the case of a discharge that endangers the health or welfare of any persons in a State other than the State in which the discharge takes place, the Secretary shall give formal notification of the existence of such pollution to the State water pollution control agency in the State in which the discharge takes place, and call a conference of the State water pollution control agencies, of the State filing the request for abatement and the State in which the discharge takes place and any interested parties, including the alleged polluter (A2). In the case of a discharge that endangers the health or welfare of only persons in the State in which the discharge takes place, the Secretary shall give formal notification of the existence of such pollution to the State water pollution control agency. He shall not call for a conference unless requested to do so by the Governor or State water pollution control agency (A3).

After the conference, if the Secretary does not think that satisfactory abatement is taking place, he shall recommend to the appropriate State water pollution control agency the taking of remedial action. The Secretary is to allow a period of six months for such remedial action to take place (A2). If the pollution is not yet abated after this period, the Secretary shall call a public meeting before a five-man Hearing Board, appointed by him. The Board will make recommendations to the Secretary, and he shall send to the guilty person the findings of the Board and recommend means of abatement. The Secretary is to allow a period of six months for such recommendations to be put into effect. If at the end of this period, the pollution is not abated, the Secretary can call upon "the Attorney General of the United States to secure abatement of the pollution" (A2).

Any person required to appear at any hearing called by the Secretary of the Interior, and whose discharges are alleged to be causing or contributing to water pollution, must file with the Secretary a report furnishing such information as "to the character, kind and quantity of such discharges and the use of facilities or other means to prevent or reduce such discharges" (A5). If such person fails to file the above report within the time specified by the Secretary, he shall be fined one hundred dollars each day he fails to file such report. The fine shall be recoverable in a civil suit to the United States (A5).

State Legislation

The Federal Government has granted the right of preventing and controlling water pollution to the individual States. Therefore, in order to determine the exact legal wastewater treatment and disposal requirements applicable to the effluents produced in a particular region of the country, a thorough study of the water pollution laws, disposal requirements and stream standards in the States located in that region is a necessity.

The textile industry is concentrated in several States located in three particular regions of the United States: the New England area, the Middle Atlantic area, and the Southeastern area. The legal aspects regarding water pollution within each particular state will be discussed.

New England

In New England, the textile wet processing industries are concentrated in Connecticut, Massachusetts, and Rhode Island. There are some firms located in the other three New England States, but these are small in size and number. These States and New York belong to the New England Interstate Water Pollution Control Commission. This Commission was set up in an effort to prevent and control pollution in the interstate waters of New England. The Commission does not have authority to involve itself in the operations of the individual State pollution control agencies (A8).

The laws of the three "Textile States" will be discussed individually in the following order: Connecticut, Massachusetts and Rhode Island. Due to the fact that all three are members of the New England Interstate Water Pollution Administration, their stream standards are similar.

Connecticut

In 1965 the governor of Connecticut formed a Clean Water Task Force to propose a new water quality act. The recommendations of this Task Force were presented to the legislature and in 1967 the Clean Water Act was adopted (A9). The new law was designed to accomplish three basic objectives. First, it gives financial assistance to municipalities and industry in the construction of pollution abatement facilities; Second, it provides the authority required by the Water Resources Commission to control and abate all the sources of water pollution in Connecticut; and Third, it authorizes the Water Resources Commission to set water quality standards to comply with Federal law and to make the communities of the State eligible for additional Federal grants. Taking up these three elements in somewhat greater detail, the law proposed:

(1) The establishment of a program to assist municipalities to finance a greatly accelerated program of sewage treatment by providing a grant of thirty percent of the cost of constructing the necessary plant and appurtenant facilities. Authorization of $150 million in State bonds is included in the act to make funding available for such grants and to advance Federal grants. Since many towns have already incurred considerable expense in constructing pollution abatement facilities prior to enactment of Public Act 57, the State will annually grant thirty percent of the principal amount of the bond or note indebtedness still outstanding in each of these communities which come due each year.

(2) Removal of State sales and use tax, State business taxes, local property taxes on, and provision for accelerated depreciation of structures and equipment used to treat industrial wastes is included to help industry and commerce to carry out their responsibilities in this area.

(3) Improvement of existing law and addition of new sections to the law to make possible more effective control of all forms of water pollution; and

(4) Additions to appropriations and facilities of the Water Resources Commission to enable this body to cope effectively with the numerous, persistent and complex problems associated with water pollution control. In addition to increased monies from the State general fund, provision has been included to make one-half of one percent of the $150 million bond authorization or $750 thousand available for administration of the clean up program. This has permitted immediate implementation of the act following signing into law on May 1, 1967 without waiting for general fund monies to become available, and it will also allow the hiring of special consultant engineering services as needed; and it permits rapid expansion and contraction of Staff in line with changing needs.

The following gives a detail description of Public Act No. 57, the Clean Water Act of 1967:

AN ACT CONCERNING THE ELIMINATION OF POLLUTION OF THE WATERS OF THE STATE

Section 1. It is found and declared that the pollution of the waters of the state is inimical to the public health, safety and welfare of the inhabitants of the state, is a public nuisance and is harmful to wildlife, fish and aquatic life and impairs domestic, agricultural, industrial, recreational and other legitimate beneficial uses of water, and that the use of public funds and the granting of tax exemptions for the purpose of controlling and eliminating such pollution is a public use and purpose for which public monies may be expended and tax exemptions granted, and the necessity and public interest for the enactment of this act and the elimination of pollution is hereby declared as a matter of legislative determination.

Section 2. As used in this act: "Commission" means the water resources commission; "waters" means all tidal waters, harbors, estuaries, rivers, brooks, watercourses, waterways, wells, springs, lakes, ponds, marshes, drainage systems, and all other surface or underground streams, bodies or accumulations of water, natural or artificial, public or private, which are contained within, flow through or border upon this state or any portion thereof; "Wastes" means sewage or any substance, liquid, gaseous, solid or radioactive, which may pollute or tend to pollute any of the waters of the state; "pollution" means harmful thermal effect or the contamination or rendering unclean or impure of any waters of the state by reason of any wastes or other material discharged or deposited therein by any public or private sewer or otherwise so as directly or indirectly to come in contact with any waters; "rendering unclean or impure" means any alteration of the physical, chemical or biological properties of any of the waters of the state, including, but not limited to, change in odor, color, turbidity or taste; "harmful thermal effect" means any significant change in the temperature of any waters resulting from a discharge therein, the magnitude of which temperature change does or is likely to render such waters harmful, detrimental or injurious to public health, safety or welfare, or to domestic, commercial, industrial, agricultural, recreational or other legitimate beneficial uses, or to livestock, wild animals, birds, fish or other aquatic life; "person" means any individual, partnership, association, firm, corporation or other entity, except a municipality, and includes any officer or governing or managing body of any partnership, association, firm or corporation; "community pollution problem" means the existence of pollution which, in the sole discretion of the commission, can best be abated by the action of a municipality; "municipality" means any metropolitan district, town, consolidated town and city, consolidated town and borough, city, borough, village, fire and sewer district, sewer district and each municipal organization having authority to levy and collect taxes or make charges for its authorized function; "discharge" means the emission of any water, substance or material into the waters of the state, whether or not such substance causes pollution; "pollution abatement facility" means treatment works which are used in the treatment of waters, including the necessary intercepting sewers, outfall sewers, pumping, power and other equipment, and their appurtenances, and includes any extensions, improvements, remodeling, additions and alterations thereof; "disposal system" means a system for disposing of or eliminating wastes, either by surface or underground methods, and includes sewage systems, pollution abatement facilities, disposal wells and other systems; "federal water pollution control act" means the Federal Water Pollution Control Act, 33 U.S.C. section 466 et seq., including amendments thereto and regulations thereunder; "order to abate pollution" includes an order to abate existing pollution or to prevent reasonably anticipated sources of pollution.

Section 3. The commission shall have the following powers and duties: (a) To exercise general supervision of the administration and enforcement of this act; (b) to develop comprehensive programs for the prevention, control and abatement of new or existing pollution of the waters of the state; (c) to advise, consult and cooperate with other agencies of the state, the federal government, other states and interstate agencies and with affected groups, political subdivisions and industries in furtherance of the purposes of this act; (d) to submit plans for the prevention and control of water pollution and to render reports and accounts to the United States secretary of the interior, the federal water pollution control administration and to any other federal officer or agency on such forms containing such information as the said secretary and the federal water pollution control administration, or any other federal officer or agency, may reasonably require, in order to qualify the state and its municipalities for grants from the United States government; (e) to encourage, participate in or conduct studies, investigations, research and demonstrations, and collect and disseminate information, relating to water pollution and the causes, prevention, control and abatement thereof; (f) to issue, modify or revoke orders prohibiting or abating pollution of the waters of the state, or requiring the construction, modification, extension or alteration of pollution abatement facilities or any parts thereof, or adopting such other remedial measures as are necessary to prevent, control or abate pollution; (g) to hold such hearings as may be required under the provisions of this act, for which it shall have the power to issue notices by certified mail, administer oaths, take testimony and subpoena witnesses and evidence; (h) to require the submission of plans, specifications and other necessary data for, and inspect the construction of, pollution abatement facilities and disposal systems in connection with the issuance of such permits or approvals as may be required by this act; (i) to issue, continue in effect, revoke, modify or deny permits, under such conditions as it may prescribe, for the discharge of any water, substance or material into the waters of the state, or orders for or approval of the installation, modification or operation of pollution abatement facilities; (j) to require proper maintenance and operation of disposal systems; (k) to exercise all incidental powers necessary to carry out the purposes of this act.

Section 4. The commission may require any person or municipality to maintain such records relating to pollution, possible pollution or the operation of pollution abatement facilities as it deems necessary to carry out the provisions of this act. The commission or any authorized representative thereof shall have access to such records, and may examine and copy any such records or memoranda pertaining thereto, or shall be furnished copies of such records on request. Such representative shall have the power to enter upon any public or private property, at reasonable times, to secure such information and the owner, managing agent or occupant of any such property shall permit such entry; provided any information relating to secret processes or methods of manufacture or production ascertained or discovered by the commission or its agents during, or as a result of, any inspection, investigation, hearing or otherwise, shall not be disclosed and shall be kept confidential.

Section 5. (a) The commission shall adopt, and may thereafter amend, standards of water quality applicable to the various waters of the state or portions thereof. Such standards shall be consistent with the federal water pollution control act and shall be for the purpose of qualifying the state and its municipalities for available federal grants and for the purpose of providing clear and objective public policy statements of a general program to improve the water resources of the state; provided no standard of water quality adopted shall plan for, encourage or permit any wastes to be discharged into any of the waters of the state without having first received the treatment available and necessary for the elimination of pollution. Such standards of quality shall: (1) Apply to interstate waters or portions thereof within the state; (2) apply to such other waters within the state as the commission may determine is necessary; (3) protect the public health and welfare and promote the economic development of the state; (4) preserve and enhance the quality of state waters for present and prospective future use for public water supplies, propagation of fish and aquatic life and wildlife, recreational purposes and agricultural, industrial and other legitimate uses; (5) be consistent with health standards as established by the state department of health. (b) Prior to adopting, amending or repealing standards of water quality, the commission shall conduct a public hearing. Notice of such hearing specifying the waters for which standards are sought to be adopted, amended or repealed and the time, date, and place of such hearing shall be published at least twice during the thirty-day period preceding the date of the hearing in a newspaper having a general circulation in the area affected and shall be given by certified mail to the chief executive officer of each municipality in such area. Prior to the hearing the commission shall make available to any interested person any information it has as to the water which is the subject of the hearing and the standards under consideration, and shall afford to any interested person the opportunity to submit to the commission any written material. At the hearing, any person shall have the right to make a written or oral presentation. A full transcript or recording of each hearing shall be made and kept available in the commission's files. (c) The commission shall establish the effective date of the adoption, amendment or repeal of standards of water quality. Notice of such adoption, amendment or repeal shall be published in the Connecticut Law Journal upon acceptance thereof by the federal government. (d) The commission shall monitor the quality of the subject waters to demonstrate the results of its program to abate pollution.

Section 6. No person or municipality shall cause pollution of any of the waters of the state or maintain a discharge of any treated or untreated wastes in violation of any provision of this act.

Section 7. If the commission finds that any municipality is causing pollution of the waters of the state, or that a community pollution problem exists, or that pollution by a municipality or a community pollution problem can reasonably be anticipated in the future, the commission shall issue to the municipality an order to abate pollution. If a community pollution problem exists in, or if pollution is caused by, a municipality geographically located all or partly within the territorial limits of another municipality, the commission shall, after giving due regard to regional factors, determine which municipality shall be ordered to abate the pollution or shall, after giving due regard to regional factors, issue an order to two or more municipalities jointly to provide the facilities necessary to abate the pollution. Such order shall include a time schedule for action by the municipality or municipalities, as the case may be, which may require, but is not limited to, the following steps to be taken by such municipality or municipalities: (a) Submission of an engineering report outlining the problem and recommended solution therefor for approval by the commission; (b) submission of contract plans and specifications for approval by the commission; (c) arrangement of financing; (d) acceptance of state and federal construction grants; (e) advertisement for construction bids; (f) start of construction; (g) placing in operation.

Section 8. If the commission finds that any person prior to the effective date of this act has caused pollution of any of the waters of the state, which pollution recurs or continues after said date, the commission shall issue an order to abate pollution to such person. The order shall include a time schedule for the accomplishment of the necessary steps leading to the abatement of the pollution. This section shall not apply to any person who is subject to the provisions of Section 9 of this act.

Section 9. (a) No person shall, after the effective date of this act, initiate, create or originate any new discharge of water, substance or material into the waters of the state without first obtaining a permit for such discharge from the commission. Application for such permit shall be on a form prescribed by the commission may therein require.

(b) If, upon receipt of an application for a permit as required in subsection (a), the commission finds that such discharge would not cause pollution of any of the waters of the state, it shall issue a permit for such discharge. If the commission finds that such discharge would cause pollution of any of the waters of the state, it shall require the applicant to submit plans and specifications of a proposed system to treat such discharge. If the commission finds that the proposed system to treat such discharge does not protect the waters of the state from pollution, it shall promptly notify the applicant that its application is denied and the reasons therefor. If any applicant, after having submitted plans and specifications pursuant to the provisions of this section for a proposed system to treat such discharge, is denied a permit by the commission, such applicant shall have the right to a hearing and an appeal therefrom in the same manner as provided for in Sections 15 and 16 of this act.

(c) The permits issued pursuant to this section shall be for a period of five years, except that any such permit shall be subject to the provisions of Section 10 of this act. Such permit: (1) Shall specify the manner, nature and volume of discharge; (2) shall require proper operation and maintenance of any pollution abatement facility required by such permit; (3) may be renewable for like periods in accordance with procedures and requirements established by the commission; and (4) shall be subject to such other requirements and restrictions as the commission deems necessary to comply fully with the purposes of this act.

(d) If the commission finds that any person has, after the effective date of the state without a permit as required in subsection (1) hereof, or in violation of such a permit, it shall, notwithstanding any request for a hearing pursuant to Section 15 of this act or the pendency of an appeal therefrom, request the attorney general to bring an action in the superior court for Hartford County to enjoin such discharge by such person until he has received a permit from the commission or has complied with a permit which the commission has issued pursuant to this section. Any such action brought by the attorney general shall have precedence in the order of trial as provided in section 52-191 of the general statutes.

Section 10. The commission shall periodically investigate and review those sources of discharge which are operating pursuant to any order, permit, directive or decision of the commission issued before or after the effective date of this act and, if it determines that there has been any substantial change in the manner, nature or volume of such discharge which will cause or threaten pollution to any of the waters of the state, or if it finds that the system treating such discharge, or the operation thereof, no longer insures or adequately protects against pollution of the waters of the state, the commission shall issue an order to abate such pollution to such person or municipality. Such order shall include a time schedule for the accomplishment of the necessary steps leading to the abatement of the pollution.

Section 11. If the commission finds that any person is maintaining any facility or condition which reasonably can be expected to create a source of pollution to the waters of the state, it shall issue an order to such person maintaining such facility or condition to take the necessary steps to correct such potential source of pollution.

Any person who receives an order pursuant to this section shall have the right to a hearing and an appeal in the same manner as is provided in sections 15 and 16 of this act. If the commission finds that the recipient of any such order fails to comply therewith, it shall request the attorney general to bring an action in the superior court for Hartford County to enjoin such person from maintaining such potential source of pollution to the waters of the state. All actions brought by the attorney general pursuant to the provisions of this section shall have precedence in the order of trial as provided in section 52-191 of the general statutes.

Section 12. Whenever the commission issues an order to abate pollution to any person pursuant to the provisions of section 8 or 10 of this act, and the commission finds that such person is not the owner of the land from which such source of pollution emanates, the commission may issue a like order to the owner of such land or shall send a certified copy of such order, by certified mail, return receipt requested, to the owner at his last-known post-office address. When the commission issues an order to an owner, the owner and the person causing such pollution shall be jointly and severally responsible. Any owner to whom an order is issued or who receives a certified copy of an order pursuant to this section shall be entitled to all notices of, and rights to participate in, any proceedings before or orders of the commission and to such hearing and rights of appeal as are provided for in sections 15 and 16 of this act.

Section 13. When the commission issues an order to any person to abate pollution, it may cause a certified copy thereof to be filed on the land records in the town wherein the land is located, and such order shall constitute a notice to the owner's heirs, successors and assigns. When the order has been fully complied with, the commission shall issue a certificate showing such compliance, which certificate the commission shall cause to be recorded on the land records in the town wherein the order was previously recorded.

Section 14. If any person or municipality fails to comply with any order to abate pollution, or any part thereof, issued pursuant to the provisions of sections 7, 8, 10 or 12 of this act, and no request for a hearing on such order or appeal therefrom is pending and the time for making such request or taking such appeal has expired, the commission shall request the attorney general to bring an action in the superior court for Hartford County to enjoin such person or municipality from maintaining such pollution and to comply fully with such order or any part thereof. All actions brought by the attorney general pursuant to the provisions of this section shall have precedence in the order of trial as provided in section 52-191 of the general statutes.

Section 15. Each order to abate pollution issued under section 7, 8 or 10 of this act shall be sent by certified mail, return receipt requested, to the subject of such order and shall be deemed issued upon deposit in the mail. Any person or municipality aggrieved by any such order may, within thirty days from the date such order is sent, request a hearing before the commission. After such hearing, the commission shall consider the facts presented to it by the person or municipality, including, but not limited to, technological feasibility, shall consider the rebuttal or other evidence presented to or by it, and shall then revise and resubmit the order to the person or municipality, or inform the person or municipality that the previous order has been affirmed and remains in effect. The request for a hearing as provided for in this section shall be a condition precedent to the taking of an appeal by the person or municipality under the provisions of section 16 of this act. The commission may, after the hearing provided for in this section, or at any time after the issuance of its order, modify such order by agreement or extend the time schedule therefor if it deems such modification or extension advisable or necessary, and any such modification or extension shall be deemed to be a revision of an existing order and shall not constitute a new order. There shall be no hearing subsequent to or any appeal from any such modification or extension.

Section 16. Any person or municipality aggrieved by any order of the commission to abate pollution may, after a hearing by the commission as provided for in section 15 of this act, appeal from the final determination of the commission based on such hearing to the superior court for Hartford County within fifteen days after the issuance of such final determination. Such final determination shall be sent by certified mail, return receipt requested, and shall be deemed issued upon deposit in the mail. Such appeal shall have precedence in the order of trial as provided in section 52-192 of the general statutes. All appeals taken pursuant to this section shall be based solely upon the record of the hearing required in section 15 of this act. The court shall determine whether the commission acted arbitrarily, unreasonably or contrary to law. If upon any such appeal, any question of law is raised which any party claims should be reviewed by the supreme court, the superior court judge shall forthwith transmit a certificate of his decision, including therein such question of law, together with a proper finding of fact, to the chief justice of the supreme court who shall thereupon call a special session of said court for the purpose of an immediate hearing upon the questions of law so certified. The chief justice of the supreme court may make such orders as will expedite said appeal, including orders specifying the manner in which the record on appeal may be prepared.

Section 17. Any person or municipality which knowingly violates any provision of this act shall forfeit to the state a sum not to exceed one thousand dollars, to be fixed by the court, for each offense. Each violation shall be a separate and distinct offense and, in case of a continuing violation, each day's continuance thereof shall be deemed to be a separate and distinct offense. The attorney general, upon complaint of the commission, shall institute a civil action to recover such forfeiture.

Section 18. The commission shall make a grant to any municipality which, after the effective date of this act, constructs, rebuilds, expands or acquires a pollution abatement facility. In the case of a municipality which, on said date, is in the process of constructing, rebuilding, expanding or acquiring such a facility, such grant shall apply only to that part of the facility constructed, rebuilt, expanded or acquired after said date. The grants under this section shall be subject to the following conditions: (1) No grant shall be made for any pollution abatement facility unless such facility, and the plans and specifications therefor, are approved by the commission, and such facility is constructed in accordance with a time schedule of the commission, and subject to such requirements as the commission shall impose. If the commission requires that the facility be approved by the federal water pollution control administration, such grant shall be conditioned upon the municipality complying with all of the requirements of said water pollution control administration; (2) no grant shall be made until the municipality has agreed to pay that part of the total cost of the facility which is in excess of the applicable state and federal grants; (3) the grant to each municipality shall equal thirty percent of the cost of such facility, which cost shall be that cost which the federal water pollution control administration uses or would use in making a federal grant, except that where the commission has approved plans for a facility exceeding the requirements of the federal act, the grant shall be thirty percent of the actual cost; (4) the state grant under this section shall be paid to the municipality in partial payments similar to the time schedule that such payments are or would be provided to the municipality by the federal water pollution control administration; (5) no grant shall be made unless the municipality assures the commission of the proper and efficient operation and maintenance of the pollution abatement facility after construction; (6) no grant shall be made unless the municipality has filed properly executed forms and applications prescribed by the commission; (7) any municipality receiving state or federal grants for pollution abatement facilities shall keep separate accounts by project for the receipt and disposal of such eligible project funds.

Section 19. The commission may provide a grant of thirty percent to a municipality for the cost of those projects which it determines to be essential to a storm and sanitary sewer separation program when it finds that such project is primarily for the separation of storm and sanitary sewage and will eliminate a substantial source of pollution. The cost of the project used to determine the state grant in this section shall not include any cost for the acquisition of land or any rights or interests therein.

Section 20. If federal funds are not available to the municipality at the time of its scheduled construction of a pollution abatement facility, the commission shall advance to such municipality, in addition to the state contribution provided for in section 18, that sum of money which would equal the amount of the federal grant, provided the municipality shall agree that any federal contribution thereafter made for the project shall be forwarded to the state as reimbursement for the funds expended under this section. Prior to advancing the federal share, the commission shall require the municipality to agree in its project contract with the commission to do all that is necessary to quality for the federal grant. The municipality shall also agree to pay over to the commission any installment of a grant received from the federal water pollution control administration on which the state has made an advance under this section. Said monies received from the municipality shall be deposited in a sinking fund which is hereby established for payment of the debt service costs of bonds issued under section 25 of this act.

Section 21. If federal funds for contract plans and specifications for the construction of a pollution abatement facility are not available to the municipality at the time of its scheduled planning, the commission shall advance to such municipality a sum equal to seven per cent of the estimated construction cost, said amount to be used by the municipality for the purpose of preparing contract plans and specifications; provided any remaining balance of the seven per cent advanced under the section shall be applied to the cost of construction of the facility. The funds advanced to the municipality under this section shall be considered a part of the total amount of the state grant provided for in section 18 of this act. Such facility shall be constructed in accordance with a schedule of the commission and shall be in conformance with an engineering report approved by the commission. Before approving the engineering report required in this section, and in section 7 of this act, and as may be required under section 10 of this act, the commission shall, among other factors, give due regard to whether such report is in conformance with its applicable guidelines, whether such report makes adequate recommendations concerning all existing and anticipated community discharges, whether such report conforms with existing planning studies and whether satisfactory considerations have been given to all regional problems outlined to the engineer in pre-report conference with the commission.

Section 22. If federal funds for an engineering report are not available, and the schedule of the commission as provided for in section 7 of this act requires that a municipality prepare such a report before July 1, 1968, and the commission finds that the charter of such municipality does not authorize a reasonable method for providing the required funds to proceed on such a report in time to accomplish its completion as scheduled, the commission may advance funds to such municipality in the amount necessary to provide such report, said funds to be used by the municipality for the purpose of preparing such report. Any funds advanced to the municipality under this section shall be considered a part of the total amount of the state grant provided for in section 18 of this act.

Section 23. The commission of agriculture and natural resources is designated as the officer of the state to manage, administer and control funds appropriated by the general assembly or authorized by the state bond commission to carry out the provisions of this act. All grants made pursuant to this act shall be made only with the advice and consent of the commissioner and no grant shall be made under this act if such grant, together with all grants awarded prior thereto, exceeds the amount of funds available therefor.

Section 24. The water resources commission is designated as the administrative agency of the state, acting with the advice and consent of the commissioner of agriculture and natural resources, to apply for and accept any funds or other aid and to cooperate and enter into contracts and agreements with the federal government relating to the planning, developing, maintaining and enforcing of the program to provide clean water and pollution abatement of the waters of the state, or for any other related purpose which the congress of the United States has authorized or may authorize. The commission, with the advice and consent of the commissioner of agriculture and natural resources, is authorized in the name of the state to make such applications, sign such documents, give such assurances and do such other things as are necessary to obtain such aid from or cooperate with the United States or any agency thereof. The commission may, with the advice and consent of the commissioner of agriculture and natural resources, enter into contracts and agreements and cooperate with any other state agency, municipality, person or other state when the same is necessary to carry out the provisions of this act. Such contracts shall be subject to the approval of the attorney general as to form.

Section 25. (a) The state bond commission is empowered to authorize the issuance of bonds of the state in one or more series in an aggregate principal amount not exceeding one hundred fifty million dollars. The proceeds of the sale of said bonds shall be used for the making of advances and grants under sections 18 to 22, inclusive, and 35 of this act and for the payment of expenses incurred by the department of agriculture and natural resources in carrying out the provisions of this act which are not otherwise provided for from the state general fund. Not more than one-half of one per cent of said proceeds shall be used for the payment of such expenses. Said bonds shall be issued in accordance with section 3-20 of the general statutes and the full faith and credit of the state are pledged for the payment of the principal of and interest on said bonds as the same become due.

(b) All of said bonds shall be payable at such place or places as may be determined by the treasurer pursuant to section 3-19 of the general statutes and shall bear such date or dates, mature at such time or times not exceeding twenty years from their respective dates, bear interest at such rate or different or varying rates and payable at such time or times, be in such denominations, be in such form with or without interest coupons attached, carry such registration and transfer privileges, be payable in such medium of payment and be subject to such terms of redemption with or without premium as, irrespective of the provisions of section 3-20 of the general statutes, may be provided in the determination authorizing the same or fixed in accordance therewith. Notwithstanding the provisions of said section 3-20, any of said bonds may be sold to the United States or any agency or instrumentality thereof in such manner and on such terms as may be provided in the determination authorizing the same or fixed in accordance therewith.

Section 26. Any town may, by ordinance, establish a special taxing district for the purpose of defraying, by taxes levied solely upon properties within such district, any of the costs of acquisition or construction of a sewerage system in accordance with the provisions of chapter 103 of the general statutes. Such special taxes shall be based upon annual budget appropriations and estimates of receipts from special benefit assessments and use charges levied with respect to such system approved by such town for the special taxing district in the manner required for the adopting of the annual budgets of such town and shall be included but shown separately in the annual tax levies of such town. Such town may, from time to time, by ordinance, alter the boundaries of such special taxing district. To meet any costs of acquisition or construction, including planning, of any such sewerage system the town may issue its general or special obligation bonds in accordance with the laws applicable thereto, the principal and interest on which shall be paid from the budgets of such special taxing district. For the purposes of this section "town" means town, consolidated town and city and consolidated town and borough.

Section 27. Subsection (51) of section 12-81 of the 1965 supplement to the general statutes is repealed and the following is substituted in lieu thereof:

(Any structure, building, machinery or other equipment after July 1, 1965, constructed, installed and used primarily for the purpose of eliminating industrial waste, or pollution of waters as defined in section 25-19. A certification by the water resources commission that such structure, building, machinery or other equipment is approved for the elimination of industrial waste or for water pollution control shall require the assessors of the town where such property is located to exempt such property from taxation. This exemption shall not apply to any water company as defined by section 16-1.) Structures and equipment acquired after July 1, 1965, for the treatment of industrial waste before the discharge thereof into any waters of the state or into any sewerage system emptying into such waters, the primary purpose of which is the reduction, control or elimination of pollution of such waters, certified as approved for such purpose by the water resources commission. For the purpose of this subsection "industrial waste" means any harmful thermal effect or any liquid, gaseous or solid substance or combination thereof resulting from any process of industry, manufacture, trade or business, or from the development or recovery of any natural resource.

Section 28. Section 12-412 of the general statutes is amended by adding subdivision (u) as follows: Sales of and the storage, use or other consumption of tangible personal property acquired for incorporation into facilities for the treatment of industrial waste before the discharge thereof into any waters of the state or into any sewerage system emptying into such waters, the primary purpose of which is the reduction, control or elimination of pollution of such waters, certified as approved for such purpose by the water resources commission. For the purposes of this subdivision "industrial waste" means any harmful thermal effect or any liquid, gaseous or solid substance or combination thereof resulting from any process of industry, manufacture, trade or business or from the development or recovery of any natural resource.

Section 29. There shall be allowed as a credit against the tax imposed by chapter 208 of the general statutes in any income year an amount equal to the product of the tax rate imposed by section 12-214 of the 1965 supplement to the general statutes for such income year multiplied by the amount of expenditures paid or incurred during such income year for the construction, rebuilding, acquisition or expansion of pollution abatement facilities, including the planning thereof, provided (a) such credit shall be allowed only with respect to pollution abatement facilities approved as such by the water resources commission, the construction, rebuilding, acquisition or expansion of which was commenced after January 1, 1967; (b) the net income for such income year and succeeding income years shall be computed without any deductions for such expenditures or for depreciation of such facilities, except to the extent the cost or other basis of such facilities may be attributable to factors other than such expenditures or in case a credit is allowable pursuant to this section for only a part of such expenditures, any deduction allowable under the federal internal revenue code for such expenditures or for depreciation of such facilities shall be proportionately reduced in computing net income for the income year and all succeeding income years; and (c) upon the sale or other disposition of such facilities in any income year the gain or loss on such sale or other disposition shall be the gain or loss which would have resulted if the cost or other basis of such facilities had been reduced by straight line depreciation based on the useful life of such facilities, except that, if such sale or other disposition occurs within three years after the date such facilities were placed in operation, the basis of such facilities for the purpose of determining gain or loss shall be zero.

Section 30. In determining gross income subject to tax under chapter 213 of the general statutes a taxpayer at its election may either deduct expenditures made or incurred for the construction, rebuilding, acquisition or expansion of pollution abatement facilities, including the planning thereof, in the income year in which such expenditures were paid or incurred, or amortize such expenditures over a period of not more than five taxable years commencing with the year in which such expenditures were paid or incurred, by deducting an equal portion thereof in each income year during such period, provided no such deduction shall be allowed with respect to expenditures made or incurred for pollution abatement facilities not approved as such by the water resources commission, or the construction, rebuilding, acquisition or expansion of which was commenced prior to January 1, 1967.

Section 31. There shall be allowed as a credit against the tax imposed by chapter 211 of the general statutes in any tax year an amount equal to the product of the tax rate imposed by section 12-258 of the 1965 supplement to the general statutes for such tax year multiplied by the amount of expenditures paid or incurred during such tax year for the construction, rebuilding, acquisition or expansion of pollution abatement facilities, including the planning thereof, provided such credit shall be allowed only with respect to pollution abatement facilities approved as such by the water resources commission, the construction, rebuilding, acquisition or expansion of which was commenced after January 1, 1967.

Section 32. There shall be allowed as a credit against the tax imposed by chapter 212 of the general statutes in any tax year an amount equal to the product of the tax rate imposed by section 12-264 of the general statutes for such tax year multiplied by the amount of expenditures paid or incurred during such tax year for the construction, rebuilding, acquisition or expansion of pollution abatement facilities, including the planning thereof, provided such credit shall be allowed only with respect to pollution abatement facilities approved as such by the water resources commission, the construction, rebuilding, acquisition or expansion of which was commenced after January 1, 1967.

Section 33. Section 25-3a of the 1965 supplement to the general statutes is repealed and the following is substituted in lieu thereof:

In all cases wherein the water resources commission is required to hold hearings, public or otherwise, on any matter within its jurisdiction, said commission may hold such hearing sitting as a body or may designate a subcommittee consisting of not fewer than three members of said commission, or may designate a member of the commission or a member of its staff to act as a hearing examiner, said subcommittee or hearing examiner to hold such hearing, at the time and place designated by said commission. When the commission designates a subcommittee to hold the hearing, one member of said subcommittee shall be designated as chairman. The subcommittee designated to hold such hearing shall be known as the hearing subcommittee. The hearing subcommittee chairman for any hearing before the subcommittee, or any member of the commission for any hearing before the commission, or the hearing examiner, may issue subpoenas, administer oaths and cause the attendance of witnesses and the production of evidence and testimony in any proceeding pending before it. The subcommittee or the hearing examiner shall, after each hearing, file with the commission a report including a finding of fact and recommendations. After considering the report of the subcommittee or the hearing examiner and the testimony of the hearing, the commission shall issue such order or permit as is applicable to the particular proceeding.

Section 34. All order, directives or decisions of the water resources commission which are in existence on the effective date of this act shall continue in force until rescinded, amended or repealed by the commission.

Section 35. The commission shall make a grant to any municipality which, prior to the effective date of this act, constructed, rebuilt, acquired or expanded a pollution abatement facility, which grant shall be thirty per cent of the principal amount of bond or note obligations of such municipality, issued to finance such construction, rebuilding, acquisition or expansion and outstanding on said date, exclusive of all interest costs and for which grant application is made on an application prescribed by the commission. Such grant shall be paid in equal annual instalments at least thirty days prior to the date the municipality is obligated to make payment on such bonds or notes, provided any grant under this section shall be reduced by any amount payable to such municipality under the provisions of section 18 of this act for the same construction, rebuilding, acquisition or expansion project, such reduction to be prorated over the period remaining for the payment of such bonds or notes.

Section 36. Sections 25-19 to 25-24, inclusive, of the general statutes, as amended, are repealed.

Section 37. This act shall take effect from its passage.

Massachusetts

In Massachusetts, the "Clean Waters Act" is the statute that provides for the control of water pollution. It was first passed in 1966 and amended in 1967, 1968 and 1969.

The Act establishes a Water Pollution Control Division in the Department of Natural Resources under the authority of the Water Resources Commission. The Division is given the duty and responsibility to enhance the quality and value of the waters and to establish programs for the prevention, control and abatement of water pollution in the Commonwealth.

In order to carry out its duty and responsibility, the Division has the following powers: to encourage the adoption and execution by users of the waters of the Commonwealth, of plans for the prevention, control and abatement of water pollution; to cooperate with the federal government, inter-state, or other states' agencies in matters related to water quality control; to receive and dispense such funds as may become available to it for the prevention, control and abatement of water pollution; to conduct a program of study and research and demonstration, either by itself or in cooperation with other agencies, relating to new and improved methods of pollution abatement or water quality control; to adopt standards of water quality for the waters of the Commonwealth and a plan for the implementation and enforcement of such standards; to examine periodically the quality of waters in the Commonwealth; to prepare and keep current comprehensive plans for the abatement of existing pollution and the prevention of further pollution; to arrange for personnel to instruct employees of water pollution control facilities in the latest and most efficient methods of water pollution control and the latest developments in the operation and maintenance of waste treatment facilities; to adopt, amend or repeal after proper hearing from time to time, rules and regulations necessary for the proper administration of the laws concerning water pollution and water quality control in the Commonwealth; to require submission of reports and plans of treatment facility construction or improvement; to inspect treatment facilities for compliance with plans and permit conditions; and to use whatever methods it considers best and most expedient to remove any spillage, seepage or filtration of oil into waters of the Commonwealth (A10).

Before any person, municipality or special district can treat or discharge sewage and/or industrial wastes; or construct facilities for the same purpose, he must obtain a permit from the Director of the Division of Water Pollution Control, and such permit shall be issued subject to such conditions as the Director "may deem necessary to insure compliance with the standards established for the waters affected". Any person owning, operating or building a water pollution abatement facility must allow for inspection of such facility by agents of the Division, and allow the inspection of records and papers pertaining to the operation of a disposal system or treatment works, providing such inspection does not allow access to confidential information such as secret formulas and economics of operation (A10).

For violation of permit regulations, for failure to allow inspection, and for causing or contributing to conditions which contravene the standards adopted by the Division of Water Pollution Control, the accused party must appear before the Division's "Regulatory Review Board" and answer the charges brought against him (A11). If this Board finds him guilty of the charges, he shall be fined one hundred dollars for each separate offense. Each day of violation shall be considered a separate offense (A10). The Director of the Division is also empowered to issue such orders or take such actions as he determines appropriate under the circumstances, to assure that the matter complained of shall be corrected; however, such actions and orders shall be subject to judicial review (A10).

The Commonwealth of Massachusetts has enacted four classifications and compiled water quality criteria within each class for both fresh (Table AI) and salt (Table AII) waters.

TABLE AI. FRESH WATERS CLASSIFICATION AND STANDARDS OF WATER QUALITY

Class A: Waters designated for use as public water supplies. Character uniformly excellent.

Standards of Quality

Item	Water Quality Criteria
1. Dissolved oxygen.	Not less than 75% of saturation during at least 16 hours of any 24-hour period and not less than 5 mg./1. at any time.
2. Sludge deposits-solid refuse-floating solids-oil-grease-scum.	None allowable.
3. Color and turbidity.	None other than of natural origin.
4. Coliform bacteria per 100 ml.	Not to exceed an average value of 50 during any monthly sampling period.

Table AI (Cont'd.) (Massachusetts)

5. Taste and odor.	None other than of natural origin.
6. pH.	As naturally occurs.
7. Allowable temperature increase.	None other than of natural origin.
8. Chemical constituents	None in concentrations or combinations which would be harmful or offensive to humans, or harmful to animal, or aquatic life.
9. Radioactivity.	None other than that occurring from natural phenomena.

Class B: Suitable for bathing and recreational purposes including water contact sports. Acceptable for public water supply with appropriate treatment. Suitable for agricultural, and certain industrial cooling and process uses; excellent fish and wildlife habitat; excellent aesthetic value.

Standards of Quality

Item	Water Quality Criteria
1. Dissolved oxygen.	Not less than 75% of saturation during at least 16 hours of any 24-hour period and not less than 5 mg./1. at any time.
2. Sludge deposits-solid refuse-floating solids-oils-grease scum.	None allowable.
3. Color and turbidity.	None in such concentrations that would impair any usages specifically assigned to this class.
4. Coliform bacteria per 100 ml.	Not to exceed an average value of 1,000 during any monthly sampling period nor 2,400 in more than 20% of samples examined during such period.
5. Taste and odor.	None in such concentrations that would impair any usages specifically assigned to this class and none that would cause taste and odor in edible fish.

Table AI (Cont'd.) (Massachusetts)

6. pH.	6.5 - 8.0.
7. Allowable temperature increase.	None except where the increase will not exceed the recommended limit on the most sensitive receiving water use and in no case exceed 83° F in warm water fisheries and 68° F in cold water fisheries, or in any case raise the normal temperature of the receiving water more than 4° F.
8. Chemical constituents.	None in concentrations or combinations which would be harmful or offensive to human, or harmful to animal or aquatic life or any water use specifically assigned to this class.
9. Radioactivity.	None in concentrations or combinations which would be harmful to human, animal, or aquatic life for the appropriate water use. None in such concentrations which would result in radio-nuclide concentrations in aquatic life which exceed the recommended limits for consumption by humans.
10. Total phosphate.	Not to exceed an average of 0.05 mg./1. as P during any monthly sampling period.
11. Ammonia.	Not to exceed an average of 0.5 mg./1. as N during any monthly sampling period.
12. Phenols.	Shall not exceed .001 mg./1. at any time.

Class C: Suitable for recreational boating; habitat for wildlife and common food and game fishes indigenous to the region; certain industrial cooling and process uses; under some conditions acceptable for public water supply with appropriate treatment. Suitable for irrigation of crops used for consumption after cooking. Good aesthetic value.

Standards of Quality

Item	Water Quality Criteria

Table A1 (Cont'd.)	(Massachusetts)
1. Dissolved oxygen.	Not less than 5 mg./1. during at least 16 hours of any 24-hour period nor less than 3 mg./1. at any time. For seasonal cold water fisheries at least 5 mg./1. must be maintained.
2. Sludge deposits-solid refuse-floating solids-oils-grease-scum.	None allowable except those amounts that may result from the discharge from waste treatment facilities providing appropriate treatment.
3. Color and turbidity.	None allowable in such concentrations that would impair any usages specifically assigned to this class.
4. Coliform bacteria.	None in such concentrations that would impair any usages specifically assigned to this class.
5. Taste and odor.	None in such concentrations that would impair any usages specifically assigned to this class, and none that would cause taste and odor to edible fish.
6. pH.	6.0 - 8.5.
7. Allowable temperature increase.	None except where the increase will not exceed the recommended limits on the most sensitive receiving water use and in no case exceed 83° F in warm water fisheries, and 68° F in cold water fisheries, or in any case raise the normal temperature of the receiving water more than 4° F.
8. Chemical constituents.	None in concentrations or combinations which would be harmful or offensive to human, or harmful to animal or aquatic life or any water use specifically assigned to this class.
9. Radioactivity.	None in concentrations or combinations which would be harmful to human, animal, or aquatic life for the appropriate water use. None in such concentrations which would result in radio-nuclide concentrations in aquatic life

		which exceed the recommended limits for consumption by humans.
10.	Total phosphate.	Not to exceed an average of 0.05 mg./1. as P during any monthly sampling period.
11.	Ammonia.	Not to exceed an average of 1.0 mg./1. as N during any monthly sampling period.
12.	Phenols.	Not to exceed an average of 0.002 mg./1. at any time.

Class D: Suitable for aesthetic enjoyment, power, navigation, and certain industrial cooling and process uses. Class D waters will be assigned only where a higher water use class cannot be attained after all appropriate waste treatment methods are utilized.

Standards of Quality

	Item	Specifications
1.	Dissolved oxygen.	Not less than 2 mg./1. at any time.
2.	Sludge deposits-solid refuse-floating solids-oils-grease-scum.	None allowable except those amounts that may result from the discharge from waste treatment facilities providing appropriate treatment.
3.	Color and turbidity.	None in such concentrations that would impair any usages specifically assigned to this class.
4.	Coliform bacteria.	None in such concentrations that would impair any usages specifically assigned to this class.
5.	Taste and odor.	None in such concentrations that would impair any usages specifically assigned to this class.
6.	pH.	6.0 - 9.0.

Table AI (Cont'd.)	(Massachusetts)
7. Allowable temperature increase.	None except where the increase will not exceed the recommended limits on the most sensitive receiving water use and in no case exceed 90° F.
8. Chemical constituents.	None in concentrations or combinations which would be harmful to human, animal, or aquatic life for the designated water use.
9. Radioactivity.	None in such concentrations or combinations which would be harmful to human, animal or aquatic life for the designated water use. None in such concentrations which will result in radio-nuclide concentrations in aquatic life which exceed the recommended limits for consumption by humans.

Source: A12, p. 2-7.

TABLE AII. COASTAL AND MARINE WATERS AND STANDARDS OF WATER QUALITY

Class SA: Suitable for any high quality water use including bathing and water contact sports. Suitable for approved shellfish areas.

Standards of Quality

Item	Water Quality Criteria
1. Dissolved oxygen.	Not less than 6.5 mg./1. at any time.
2. Sludge deposits-solid refuse-floating solids-oil-grease-scum.	None allowable.
3. Color and turbidity.	None in such concentrations that will impair any usages specifically assigned to this class.

Table AII (Cont'd.) (Massachusetts)

4.	Coliform bacteria per 100 ml.	Not to exceed a median value of 70 and not more than 10% of the samples shall ordinarily exceed 230 during any monthly sampling period.
5.	Taste and odor.	None allowable.
6.	pH.	6.8 - 8.5.
7.	Allowable temperature increase.	None except where the increase will not exceed the recommended limits on the most sensitive water use.
8.	Chemical constituents.	None in concentrations or combinations which would be harmful to human, animal, or aquatic life or which would make the waters unsafe or unsuitable for fish or shellfish or their propagation, impair the palatability of same, or impair the waters for any other uses.
9.	Radioactivity.	None in concentrations or combinations which would be harmful to human, animal or aquatic life for the designated water use. None in such concentrations which would result in radinuclide concentrations in aquatic life which exceed the recommended limits for consumption by humans.
10.	Total phosphate.	Not to exceed an average of 0.07 mg./1. as P during any monthly sampling period.
11.	Ammonia.	Not to exceed an average of 0.2 mg./1. as N during any monthly sampling period.

Class SB: Suitable for bathing and recreational purposes including water contact sports; industrial cooling; excellent fish habitat; good aesthetic value; and suitable for certain shellfisheries with depuration. (Restricted Shellfish Areas).

Standards of Quality

Item	Water Quality Criteria

Table AII (Cont'd)	(Massachusetts)
1. Dissolved oxygen.	Not less than 5.0 mg./l. at any time.
2. Sludge deposits-solid refuse-floating solids-oils-grease-scum.	None allowable.
3. Color and turbidity.	None in such concentrations that would impair any usages specifically assigned to this class.
4. Coliform bacteria per 100 ml.	Not to exceed a median value of 700 and not more than 2,300 in more than 10% of the samples during any monthly sampling period.
5. Taste and odor.	None in such concentrations that would impair any usages specifically assigned to this class and none that would cause taste and odor in edible fish or shellfish.
6. pH.	6.8 - 8.5.
7. Allowable temperature increase.	None except where the increase will not exceed the recommended limits on the most sensitive water use.
8. Chemical constituents.	None in concentrations or combinations which would be harmful to human, animal or aquatic life or which would make the waters unsafe or unsuitable for fish or shellfish or their propagation, impair the palatability of same, or impair the water for any other usage.
9. Radioactivity.	None in concentrations or combinations which would be harmful to human, animal, or aquatic life for the appropriate water use. None in such concentrations which would result in radio-nuclide concentrations in aquatic life which exceed the recommended limits for consumption by humans.
10. Total phosphate.	Not to exceed an average of 0.07 mg./l. as P during any monthly sampling period.

Table AII (Cont'd.) (Massachusetts)

11. Ammonia.	Not to exceed an average of 0.2 mg./1. as N during any monthly sampling period.

Class SC: Suitable for aesthetic enjoyment; for recreational boating; habitat for wildlife and common food and game fishes indigenous to the region; industrial cooling and process uses.

Standards of Quality

Item	Water Quality Criteria
1. Dissolved oxygen.	Not less than 5 mg./1. during at least 16 hours of any 24-hour period or less than 3 mg./1. at any time.
2. Sludge deposits-solid refuse-floating solids-oils-grease-scum.	None except that amount that may result from the discharge from a waste treatment facility providing appropriate treatment.
3. Color and turbidity.	None in such concentrations that would impair any usages specifically assigned to this class.
4. Coliform bacteria.	None in such concentrations that would impair any usages specifically assigned to this class.
5. Taste and odor.	None in such concentrations that would impair any usages specifically assigned to this class and none that would cause taste and odor in edible fish or shellfish.
6. pH.	6.5 - 8.5.
7. Allowable temperature increase.	None except where the increase will not exceed the recommended limits on the most sensitive water use.
8. Chemical constituents.	None in concentrations or combinations which would be harmful to human, animal or aquatic life or which would make the waters unsafe or unsuitable for fish or shellfish or their propagation, impair the palatability of same, or impair the water for any other usage.

Table AII (Cont'd.) (Massachusetts)

9.	Radioactivity.	None in such concentrations which would be harmful to human, animal or aquatic life for the designated water use. None in such concentrations which would result in radio-nuclide concentrations in aquatic life which exceed the recommended limits for consumption by humans.
10.	Total phosphate.	Not to exceed an average of 0.07 mg./1. as P during any monthly sampling period.
11.	Ammonia.	Not to exceed an average of 1.0 mg./1. as N during any monthly sampling period.

Source: A12. p. 9-12

The Division of Water Pollution Control requires that the wastes discharged to fresh waters in the Commonwealth receive secondary treatment with disinfection or its industrial waste treatment equivalent, except when a higher degree of treatment is required to meet water quality standards. Disinfection may be discontinued during the period of October 1 to May 1, at the discretion of the Division. In the period May 2 to September 30, the disinfection requirements are to be "equivalent to a free and combined chlorine residual of at least 1.0 milligram per liter after 15 minutes contact time during peak hourly flow or maximum rate of pumpage " (A12). For coastal and marine waters the appropriate treatment is that degree of treatment with disinfection required for the receiving waters to meet their assigned classification and water quality standards. As in fresh water disinfection, the Division may grant permission to discontinue chlorination during the period of October 1 to May 1. The required dosage of free and combined chlorine is the same as that required of effluents discharged to fresh waters (A12).

The Commonwealth of Massachusetts exempts from local property taxes any equipment or facility installed for the purpose of abating or preventing pollution of any waters of the Commonwealth. The Commonwealth also allows for the accelerated depreciation of capital investments used in approved waste treatment facilities on state corporate taxes (A13).

In Massachusetts, the textile industry is well spread throughout the state with a large concentration in New Bedford. The firm sizes vary from small to very large. At present there has been no extensive research on textile water waste problems in Massachusetts; however, a recent article in a trade journal relates the closing of two Massachusetts wool scouring mills as a result of a tough new stand against pollution by the Division of Water Pollution (A14). Both firms have had to close because their effluent discharges contravened the established standards of the receiving streams, and they could not afford the expense of building pre-treatment facilities. Although firms located in large cities and towns probably discharge their effluents to municipal treatment facilities; firms which have previously been dumping untreated or slightly treated effluents in the Commonwealth waters may find that they too will have to close down or build expensive treatment facilities.

Rhode Island

The control of water pollution in the State of Rhode Island is governed by the "Water Pollution Laws, Title 46, Chapter 12 of 1956" as amended in 1958, 1963 and 1966. The laws create a five member advisory Water Pollution Board, which has the function of assisting the State Department of Health which the laws designate as the state water pollution control agency.

The Board's only function is to advise the Department of Health on matters concerning water pollution, when asked to do so by the Department. The Department has nine board powers it can exercise. They are: advise, consult and cooperate with federal and other state agencies in matters that relate to the control of pollution; accept and administer loans and grants; conduct studies, investigations, research and demonstrations concerning water pollution problems; collect and disseminate information from aforementioned studies, investigations, research and demonstrations to persons requiring technical assistance in water waste disposal projects; adopt, modify and repeal water classifications and standards; require the submission of plans for the construction of new, or the modification of existing waste treatment facilities and inspect such construction; consult the advisory board; and make, amend and revoke pollution control rules and regulations (A13).

The state requires permits for the operation, construction or renovation of a waste treatment facility. This permit must be obtained from the Director of the Rhode Island Department of Public Health. The Department has a rule that prohibits the approval of a permit for an individual waste treatment facility, "if a public sanitary sewer is reasonably accessible" to the premises (A15).

The Department of Health requires a minimum B. O. D. and suspended solids removal of 85 percent (by weight) unless dilution requirements demand higher removals. Where dilution requirements are more than sufficient in estuarine waters, primary treatment may be employed (A16).

The state also requires the disinfection of all waste effluents, that may contain organisms that could influence public health conditions, by chlorination. The Department of Health requires one milligram per liter of chlorine added after 15 minutes detention time to secondary treatment facilities and two milligrams per liter of chlorine for primary plants after the 15 minutes detention.

For the violation of permit regulations, for causing pollution or failure to treat effluents in the proper manner, the "Water Pollution Laws" of Rhode Island penalize such persons a fine of five hundred dollars and/or 30 days in jail for each separate offense. The Department of Health is to consider each day of continued violation as a separate offense (A13).

The State of Rhode Island has instituted a set of classifications and water quality criteria for each classification for both fresh (Table AIII) and salt (Table AIV) Water.

TABLE AIII. FRESH WATER CLASSIFICATIONS AND WATER QUALITY CRITERIA

Class A: Suitable for water supply and all other water uses; character uniformly excellent. Waters in use for drinking water supply may be subject to restricted use by state and local authorities.

Standards of Water Quality

1.	Dissolved oxygen.	75% saturation, 16 hours/day 5 mg./1. at any time.
2.	Sludge deposits-solid refuse-floating solids, oils, and grease-scum.	None allowable.
3.	Color and turbidity.	None other than of natural origin.
4.	Coliform bacteria per 100 ml.	Not to exceed a median of 100 per 100 ml. nor more than 500 in more than 10% of samples collected.

Table AIII (Cont'd.) (Rhode Island)

5. Taste and odor.	None other than of natural origin.
6. pH.	As naturally occurs.
7. Allowable temperature increase.	None other than of natural origin.
8. Chemical constituents.	None in such concentrations or combinations which would be harmful to human, animal, or aquatic life. The limits prescribed by the United States Public Health Service are to be used as a guideline.

Class B: Suitable for bathing, other recreational purposes, agricultural uses, industrial processes and cooling; excellent fish and wildlife habitat; good aesthetic value; acceptable for public water supply with appropriate treatment.

Standards of Water Quality

1. Dissolved oxygen.	75% saturation, 16 hours/day 5 mg./1. at any time.
2. Sludge deposits-solid refuse-floating solids, oils, and grease-scum.	None allowable.
3. Color and turbidity.	None in such concentrations that would impair any usages specifically assigned to this class.
4. Coliform bacteria per 100 ml.	Not to exceed a median of 1,000 per 100 ml. nor more than 2,400 in more than 20% of samples collected.
5. Taste and odor.	None in such concentrations that would impair any usages specifically assigned to this Class nor cause taste and odor in edible fish.
6. pH.	6.5 - 8.0.

Table AIII (Cont'd.)	(Rhode Island)
7. Allowable temperature increase.	Only such increases that will not impair any usages specifically assigned to this Class. The temperature increase shall not raise the temperature of the receiving waters above 68° F for waters supporting cold water fisheries and 83° F for waters supporting a warm water fishery. In no case shall the temperature of the receiving water be raised more than 4° F.
8. Chemical constituents.	None in such concentrations or combinations which would be harmful to human, animal or aquatic life. For public drinking water supplies, the limits prescribed by the United States Public Health Service are to be used as a guideline. In areas where fisheries are the governing considerations and approved limits have not been established, bioassays shall be performed as required by the Department of Health.

Class C: Suitable for fish and wildlife habitat; recreational boating, and industrial processes and cooling; under some conditions acceptable for public water supply with appropriate treatment; good aesthetic value.

Standards of Water Quality

1. Dissolved oxygen.	5 mg./1., 16 hours/day; not less than 3 mg./1. at any time. For cold water fishery not less than 5 mg./1. at any time.
2. Sludge deposits-solid refuse, floating solids, oils, and grease-scum.	None shall be allowed except for such small amounts that may result from the discharge of appropriately treated sewage or industrial waste effluents.
3. Color and turbidity.	None in such concentrations that would impair any usages specifically assigned to this class.
4. Coliform bacteria per 100 ml.	None in such concentrations that would impair any usages specifically assigned to this class.

Table AIII (Cont'd.) (Rhode Island)

5. Taste and odor.	None in such concentrations that would impair any usages specifically assigned to this Class nor cause taste and odor in edible fish.
6. pH.	6.0 - 8.5.
7. Allowable temperature increase.	Only such increases that will not impair any usages specifically assigned to this Class. The temperature increase shall not raise the temperature of the receiving waters above 68° F for waters supporting cold water fisheries and 83° F for waters supporting a warm water fishery. In no case shall the temperature of the receiving water be raised more than 4° F.
8. Chemical constituents.	None in such concentrations or combinations which would be harmful to human, animal or aquatic life. For public drinking water supplies, the limits prescribed by the United States Public Health service are to be used as a guideline. In areas where fisheries are the governing considerations and approved limits have not been established, bio-assays shall be performed as required by the Department of Health.

Class D: Suitable for navigation, power, certain industrial processes and cooling, and migration of fish; good aesthetic value. This class will be assigned only where a higher water use class cannot be attained after all appropriate waste treatment methods are utilized.

Standards of Water Quality

1. Dissolved oxygen.	A minimum of 2 mg./1. at any time.
2. Sludge deposits-solid refuse-floating solids, oils, and grease-scum.	None shall be allowed except for such small amounts that may result from the discharge of appropriately treated sewage or industrial waste effluents.
3. Color and turbidity.	None in such concentrations that would impair any usages specifically assigned to this Class.

Table AIII (Cont'd.) (Rhode Island)

4. Coliform bacteria per 100 ml.	None in such concentrations that would impair any usages specifically assigned to this Class.
5. Taste and odor.	None in such concentrations that would impair any usages specifically assigned to this Class.
6. pH.	6.0 - 9.0.
7. Allowable temperature increase.	None except where the increase will not exceed the recommended limits on the most sensitive water use and in no case exceed 90° F.
8. Chemical constituents.	None in such concentrations or combinations which would be harmful to human, animal or aquatic life.

Class E: Waters falling below the standards of quality of Class D shall receive this classification and considered to be a nuisance and unsuitable for most uses.

Source: A17 p. 2-6

TABLE AIV. SALT WATER CLASSIFICATIONS AND WATER QUALITY CRITERIA

Class SA: Suitable for all sea water uses including shellfish harvesting for direct human consumption (approved shellfish areas), bathing, and other water contact sports.

Standards of Quality

1. Dissolved oxygen.	Not less than 6.0 mg./1. at any time.
2. Sludge deposits-solid refuse-floating solids, oil, grease, scum.	None allowable.

Table AIV (Cont'd.) (Rhode Island)

3. Color and turbidity.	None in such concentrations that will impair any usages specifically assigned to this Class.
4. Coliform bacteria per 100 ml.	Not to exceed a median MPN of 70 and not more than 10% of the samples shall ordinarily exceed an MPN of 230 for a 5-tube decimal dilution of 330 for a 3-tube decimal dilution. Samples shall be taken during periods when the most unfavorable hydrographic and pollution conditions prevail.
5. Odor.	None allowable.
6. pH.	6.8 - 8.5.
7. Allowable temperature increase.	None except where the increase will not exceed the recommended limits for the most sensitive water use.
8. Chemical constituents.	None in concentrations or combinations which would be harmful to human, animal, or aquatic life or which would make the waters unsafe or unsuitable for fish or shellfish or their propagation, impair the palatability of same, or impair the waters for any other uses.
9. Radioactivity.	None in concentrations or combinations which would be harmful to human, animal or aquatic life.

Class SB: Suitable for bathing, other recreational purposes, industrial cooling and shellfish harvesting for human consumption after depuration (restricted shellfish area); excellent fish and wildlife habitat; good aesthetic value.

Standards of Quality

1. Dissolved oxygen.	Not less than 5.0 mg./1. at any time.
2. Sludge deposits-solid refuse, floating solids-oils, grease,scum.	None allowable.

Table AIV (Cont'd.)	(Rhode Island)
3. Color and turbidity.	None in such concentrations that would impair any usages specifically assigned to this class.
4. Coliform bacteria per 100 ml.	Not to exceed a median value of 700/100 ml. and not more than 2,300 in more than 10 percent of the samples. Samples should be taken during periods when the most unfavorable hydrographic and pollution conditions prevail.
5. Taste and odor.	None in such concentrations that would impair any usages specifically assigned to this Class and none that would cause taste and odor in edible fish or shellfish.
6. pH.	6.8 - 8.5.
7. Allowable temperature increase.	None except where the increase will not exceed the recommended limits on the most sensitive water use assigned to this class.
8. Chemical constituents.	None in concentrations or combinations which would be harmful to human, animal, or aquatic life or which would make the waters unsafe or unsuitable for fish or shellfish or their propagation, or impair the water for any other usage assigned to this class.
9. Radioactivity.	None in concentrations or combinations which would be harmful to human, animal or aquatic life.

Class SC: Suitable for fish, shellfish, and wildlife habitat; suitable for recreational boating, and industrial cooling; good aesthetic value.

Standards of Quality

1. Dissolved oxygen.	Not less than 5 mg./l. during at least 16 hours of any 24 hour period nor less than 3 mg./l. at any time.
2. Sludge deposits-solid refuse,	None except that amount that may result from

Table AIV (Cont'd.)	(Rhode Island)
2. (Cont'd.) floating solids-oils, grease, scum.	the discharge from a waste treatment facility providing appropriate treatment.
3. Color and turbidity.	None in such concentrations that would impair any usages specifically assigned to this class.
4. Coliform bacteria.	None in such concentrations that would impair any usages specifically assigned to this class.
5. Taste and odor.	None in such concentrations that would impair any usages specifically assigned to this class and none that would cause taste and odor in edible fish or shellfish.
6. pH.	6.5 - 8.5.
7. Allowable temperature increase.	None except where the increase will not exceed the recommended limits on the most sensitive water use assigned to this class.
8. Chemical constituents.	None in concentrations or combinations which would be harmful to human, animal, or aquatic life or which would make the waters unsafe or unsuitable for fish or shellfish or their propagation, or impair the water for any other usage assigned to this class.
9. Radioactivity.	None in concentrations or combinations which would be harmful to human, animal or aquatic life.

Class SD: Suitable for navigation, industrial cooling and migration of fish; good aesthetic value. This class will be assigned only where a higher water use class cannot be attained after appropriate waste treatment methods are utilized.

Standards of Quality

1. Dissolved oxygen.	Not less than 2 mg./1. at any time.
2. Sludge deposits-solid refuse,	None except that amount that may result from

Table AIV (Cont'd.) (Rhode Island)

2.	(Cont'd.) floating solids, oils, grease, scum.	the discharge from a waste treatment facility providing appropriate treatment.
3.	Color and turbidity.	None in such concentrations that would impair any usages specifically assigned to this class.
4.	Coliform bacteria.	None in such concentrations that would impair any usages specifically assigned to this class.
5.	Taste and odor.	None in such concentrations that would impair any usages specifically assigned to this class and none that would cause taste and odor in edible fish or shellfish.
6.	pH.	6.5 - 8.5.
7.	Allowable temperature increase.	None except where the increase will not exceed the recommended limits on the most sensitive water use.
8.	Chemical constituents.	None in concentrations or combinations which would be harmful to human, animal, or aquatic life or which would make the waters unsafe or unsuitable for fish or shellfish or their propagation, impair the palatability of same, or impair the water for any other usage.
9.	Radioactivity.	None in concentrations or combinations which would be harmful to human, animal or aquatic life.

Class SE: Water falling below the standards of quality of Class SD shall receive this classification and considered to be a nuisance and unsuitable for most uses.

Source: (A17, p. 9-12)

(Rhode Island)

In Rhode Island, the textile industry is located throughout the state with a particular concentration in the towns of Woonsocket, Providence and West Warwick. Most of the firms are located in towns of moderate or large size. The size of firms varies from very large to small. No extensive study is available on the textile water waste problems of the state; however, due to the Department of Health's regulation prohibiting private treatment plants if sewers exist that are easily accessible, a reasonable conclusion would be that the mills use municipal sewage systems to dispose of their liquid wastes.

Middle Atlantic States

Three states (New Jersey, New York, and Pennsylvania) in the Middle Atlantic region have large concentrations of textile water waste producing firms. New York belongs to the New England Interstate Water Pollution Control Commission and has adopted standards consistent with those of the Commission. There is little similarity in the standards of these three states. The laws of these three states are presented in the following order: New Jersey, New York, and Pennsylvania.

New Jersey

Chapter 210, Public Law 1899 as amended governs water pollution control efforts in the State of New Jersey. Chapter 12 of Title 58 of the Revised Statutes of New Jersey empowers the State Department of Health with complete control of effluent discharge to state waters, setting of stream standards, classification of streams, issuance of disposal discharge permits and inspection of treatment facilities (A18).

Once a permit has been issued, any violation of its conditions of issuance or failure to comply to state effluent standards can result in fines ranging from $100 to $2,500 per day depending on the seriousness of the violation. Court injunctions are usually the first form of state sanction in New Jersey. When pollution is first discovered, the person or municipality guilty of the condition is served an injunction to cease polluting practices. If the party fails to comply with the injunction, then the State Attorney General is empowered to impose said fines.

The Department of Health employs civil and sanitary engineers who can be used as consultants to municipalities and industrial firms for guidance, direction and information. The State also allows for exemption from all real and personal property taxes equipment and facilities used for water pollution control provided they do not lead to the recovery of by-products sold to obtain profits.

The waterways in New Jersey are divided into three broad groups; non-tidal fresh water, tidal surface waters, and coastal waters. Within each group are a number of classifications - three for fresh surface water (F.W.), three for tidal waters (T.W.), and two for the coastal waters (C.W.). Table AV lists the Classification and Standards Quality for the State of New Jersey.

TABLE AV. CLASSIFICATION AND STANDARD OF QUALITY FOR NEW JERSEY STATE SURFACE WATERS

Class F.W.-1

Definition: Fresh surface waters designated by authorized state agencies as being set aside for posterity to represent the natural aquatic environment and its associated biota.

Criteria: These waters shall be maintained, as to quality, in their natural state.

Class F.W.-2

Definition: Fresh surface waters approved as sources of public potable water supply. These waters are to be suitable for public potable water supply after such treatment as shall be required by the State Department of Health. These waters shall be suitable also for all recreational purposes including fishing, the propagation and migration of native fish species desired for angling and other fish and aquatic life necessary thereto as well as any other reasonable uses.

Criteria:

Conditions	Allowable Limits
1. Floating solids, settable solids, oil, grease, artificial coloring matter and turbidity.	- None of which are noticeable in the water or are deposited along the shore or on the aquatic substrata in quantities detrimental to the natural biota.
2. Toxic or deleterious substances (including mineral acids, caustic alkali, cyanides, heavy metals, carbon dioxide, ammonia or ammonium compounds, chlorine, etc.	- None of which would effect humans or be detrimental to the natural aquatic biota.

Table AV (Cont'd) (New Jersey)

3. Odor and taste producing substances.	None of which are offensive to humans, detrimental to the aquatic biota or capable of producing offensive tastes and/or odors in water supplies and fauna used for human consumption.
4. pH.	Between 6.5 and 8.5 unless naturally outside thereof.
5. Dissolved oxygen.	Not less than 5.0 p.p.m for trout waters; otherwise 4.0 p.p.m.
6. Thermal discharges	None of which detrimentally affect the natural aquatic biota, or reasonable anticipated reuse of the waters.

Class F.W.3

Definition: Fresh surface waters suitable for all purposes provided for under Class F.W.-2 except public potable water supply.

Criteria:

Conditions	Allowable Limits
1. Floating solids, settleable solids, oil, grease, and turbidity.	None of which are noticeable in the water or are deposited along the shore or on the aquatic substrata in quantities detrimental to the natural biota.
2. Toxic or deleterious substances (including mineral acids, caustic alkali, cyanides, heavy metals, carbon dioxide, ammonia or ammonium compounds, chlorine, etc.	None of which would affect humans or be detrimental to the natural aquatic biota.
3. Color, odor and taste producing substances.	None of which are offensive to humans, detrimental to the aquatic biota or capable of producing offensive tastes and/or odors in fauna used for human consumption.

Table AV (Cont'd.) (New Jersey)

4. pH.	- Between 6.5 and 8.5 unless naturally outside thereof.
5. Dissolved oxygen.	- Not less than 5.0 p.p.m. for trout waters; otherwise 4.0 p.p.m.
6. Thermal discharges.	- None of which detrimentally affect the natural aquatic biota, or reasonable anticipated reuse of the waters.

Class T.W.-1

Definition: Tidal surface waters suitable for all recreational purposes, as a source of public potable water supply where permitted, and, where shellfishing is permitted, to be suitable for such purposes.

Criteria:

Conditions	Allowable Limits
1. Floating solids, settleable solids, oil, grease, sleek and turbidity.	- None of which are noticeable in the water or are deposited along the shore or on the aquatic substrata in quantities detrimental to the natural biota.
2. Toxic or deleterious substances (including mineral acids, caustic alkali, cyanides, heavy metals, carbon dioxide, ammonia or ammonium compounds, chlorine, etc.).	- None of which would affect humans or be detrimental to the natural aquatic biota.
3. Color, odor and taste producing substances.	- None of which are offensive to humans, detrimental to the aquatic biota or capable of producing offensive tastes and/or odors in water supplies and fauna used for human consumption.
4. pH.	- Between 6.5 and 8.5 unless naturally outside thereof.
5. Dissolved oxygen.	- Not less than 50% of saturation.

Table AV (Cont'd.) (New Jersey)

6. Thermal discharges.	- None of which detrimentally affect the natural aquatic biota, or reasonably anticipated reuse of the waters.
7. Coliform bacteria.	- The median MPN value in shellfish growing areas shall not be in excess of 70 per 100 milliliters.

Class T.W.-2

Definition: Tidal surface waters having limited recreational value and ordinarily not acceptable for bathing but suitable for fish survival although perhaps not suitable for fish propagation. These waters shall not be an odor nuisance and shall not cause damage to pleasure craft having occasion to traverse the waters.

Criteria:

Conditions	Allowable Limits
1. Floating solids, oil and grease.	- None of which are noticeable in the water or contribute to the formation of sludge along the shores.
2. Toxic and deleterious substances.	- None in such concentrations as to cause fish mortality or inhibit their natural migration.
3. Taste and odor-producing substances.	- None, either alone or in combination, which are offensive or that would produce offensive tastes and/or odors in fauna used for human consumption.
4. pH.	- Between 6.5 and 8.5 unless naturally outside thereof.
5. Dissolved oxygen.	- Not less than 50% saturation.
6. Thermal discharges.	- None which detrimentally affect reasonable anticipated reuse of the waters.

Table AV (Cont'd.) (New Jersey)

Class T.W.-3

Definition: Tidal surface waters used primarily for navigation, not recreation. These waters, although not expected to be used for fishing, shall provide for fish survival. These waters shall not be an odor nuisance and shall not cause damage to pleasure craft traversing them.

Criteria:

Conditions		Allowable Limits
1. Floating solids, settleable solids, oil and grease.	-	None of which are noticeable in the water or contribute to the formation of sludge deposits along the shores.
2. Toxic and deleterious substances.	-	None in such concentrations as to cause fish mortality or inhibit their natural migration.
3. Taste and odor producing substances.	-	None of which shall be offensive or that would detrimentally affect finfish, shellfish or other aquatic life in higher quality waters.
4. pH.	-	Between 6.5 and 8.5 unless naturally outside thereof.
5. Dissolved oxygen.	-	Not less than 30% of saturation or 3.0 p.p.m., whichever is less.

Class C.W.-1

Definition: Atlantic Ocean waters within 1500 feet from mean low tide or to a depth of 15 feet, whichever is more distant from the mean low tide line, and expected to be suitable for all recreational purposes including fishing, the propagation and migration of native fish species desired for angling and other fish and aquatic life necessary thereto as well as any other reasonable use.

Criteria:

Conditions

Allowable Limits

Table AV (Cont'd.) (New Jersey)

1.	Floating solids, settleable solids, oil, grease and turbidity.	-	None of which are noticeable in the water or contribute to the formation of sludge deposits along the shores.
2.	Toxic and deleterious substances.	-	None of which would affect humans or be detrimental to the natural aquatic biota.
3.	Color, taste and odor producing substances.	-	None of which are offensive to humans, capable of producing offensive tastes and/or odors in fauna used for human consumption.
4.	pH.	-	Between 6.5 and 8.5 unless naturally outside thereof.
5.	Dissolved oxygen.	-	Not less than 50% saturation.
6.	Thermal discharges.	-	None which detrimentally affect the natural aquatic biota.

Class C.W.-2

Definition: Atlantic Ocean waters out to the three (3) mile limit, expected to be suitable for all recreational uses, including those in Class C.W.-1, except bathing.

Criteria:

	Conditions		Allowable Limits
1.	Floating solids, settleable solids, oil, grease and turbidity.	-	None of which are noticeable in the water or contribute to the formation of sludge deposits along the shores.
2.	Toxic and deleterious substances.	-	None of which would affect humans or be detrimental to the natural aquatic biota.
3.	Color.	-	None which would impair the quality of C.W.-1 water or be detrimental to aquatic biota.

Table AV (Cont'd.) (New Jersey)

4. Taste and odor producing substances.	- None of which are offensive to humans, or capable of producing tastes and/or odors in fauna used for human consumption.
5. Dissolved oxygen.	- Not less than 50% saturation.
6. Thermal discharges	- None which detrimentally affect the natural aquatic biota.

Source: A19

There are seven river basins in New Jersey; the Delaware, Hackensack, Passaic, Wallkill, Atlantic Coastal Plain, and the Hudson River Basin including Arthur Kill and its tributaries. The Department of Health has set up specific "regulations concerning treatment of wastewaters, domestic and industrial, separately or in combination" for the first six areas. The regulations for the seventh are still under consideration, due to its being affected by New York state waters a joint resolution will probably be passed.

The Department of Health's engineers use the above criteria to classify the state's streams. When the classification of a basin's surface waters is complete, the Department studies the waters' present condition, and based on the desired conditions passes the specific regulations for the particular basin. Each of the six basins that have specific regulations have been passed by the state legislature as separate bills. Two provisions are the same for each bill:

1) "It is recognized, especially in connection with some industrial wastes, that the pollution load imposed upon the waters of the basin cannot be evaluated fully exclusively by the biochemical oxygen demand test; therefore, each industrial waste problem shall be considered individually and treatment shall be required as needed to effect compliance with the Water Quality Standards established for the various classifications of waters in the basin.

2) Treatment standards set by these regulations are the minimum acceptable for the basin. Treatment more intense than that specified herein above shall be provided whenever it is determined by the State Department of Health that such treatment is necessary." (A19)

(New Jersey)

The specific regulations covering treatment of waste waters discharged to the Delaware River Basin are:

> "Henceforth, industrial wastes (separately or in combination with domestic wastes), prior to discharge into waters of the Delaware River Basin classified as F.W.-2, F.W.-3, T.W.-1 and T.W.-2, shall be treated to a degree providing, as a minimum, ninety percent (90%) of reduction of biochemical oxygen demand at all times and such further reduction of biochemical oxygen demand as may be necessary to maintain the receiving waters, after reasonable effluent dispersion, as specified in the regulations entitled 'Regulations Concerning Classification of the Surface Waters of the Delaware River Basin, Being Waters of the State of New Jersey', effective July 28, 1967; it is an objective of this regulation that the biochemical oxygen demand of effluents discharged shall not exceed twenty-five (25) parts per million." (A20)

The specific regulations of the waste water treatment required for surface waters in the Hackensack River Basin are:

> "Henceforth, industrial wastes (separately or in combination with domestic wastes), prior to discharge into waters of the Hackensack River Basin, classified as F.W.-2, F.W.-3 or T.W.-1 shall be treated to a degree providing, as a minimum, ninety percent (90%) of reduction of biochemical oxygen demand at all times and such further reduction in biochemical oxygen demand as may be necessary to maintain water in the River after dispersion of treated industrial waste effluents as specified in the rules and regulations entitled 'Regulations Concerning Classification of the Surface Waters of the Hackensack River Basin', effective March 1, 1966; it is the objective of this regulation that the biochemical oxygen demand of effluents discharged shall not exceed twenty-five (25) parts per million.
>
> Henceforth, industrial wastes prior to discharge into waters of the Hackensack River Basin classified as T.W.-2 or T.W.-3, shall be treated to a degree providing, as a minimum, eighty percent (80%) of reduction of biochemical oxygen demand at all times and such further reduction of biochemical oxygen demand as may be necessary in order to maintain the waters of the river of a quality as specified by the rules and regulations entitled 'Classification of the Surface Waters of the Hackensack River Basin', effective March 1, 1966; it is the objective of this regulation that the biochemical

> oxygen demand of effluents discharged shall not exceed 50 parts per million." (A21)

The Passaic River Basin and Newark Bay are governed by the following regulations:

> "Henceforth, industrial wastes (separately or in combination), prior to discharge into the waters of the Passaic River Basin, classified as F.W.-2, or F.W.-3, shall be treated to a degree providing, as a minimum, ninety percent (90%) of reduction of biochemical oxygen demand at all times and such further reduction in the biochemical oxygen demand as may be necessary to maintain water in the river after dispersion of treated industrial waste effluents as specified in the rules and regulations entitled 'Regulations Concerning Classification of the Surface Waters of the Passaic River Basin', effective September 11, 1966; it is the objective of this regulation that the biochemical oxygen demand of effluents discharged shall not exceed twenty-five (25) parts per million.
>
> Henceforth, industrial wastes (separately or in combination with domestic wastes), prior to discharge into the waters of the Passaic River Basin, classified as T.W.-2 or T.W.-3, shall be treated to a degree providing, as a minimum, eighty percent (80%) of reduction of biochemical oxygen demand at all times, and such further reduction of biochemical oxygen demand as may be necessary in order to maintain the waters of the River of a quality as specified by the rules and regulations entitled 'Classification of the Surface Waters of the Passaic River Basin', effective September 11, 1966; it is the objective of this regulation that the biochemical oxygen demand of effluents discharged shall not exceed fifty (50) parts per million." (A22)

The following regulations apply to the Raritan River Basin, including Raritan Bay:

> "Henceforth, industrial wastes (separately or in combination with domestic wastes), prior to discharge into waters of the Raritan River Basin, classified as F.W.-2 or F.W.-3, shall be treated to a degree providing as a minimum, ninety percent (90%) of reduction of biochemical oxygen demand at all times and such further reduction in biochemical oxygen demand as may be necessary to maintain water in the river after dispersion of treated industrial waste effluents as specified in the rules and regulations entitled 'Classification of the Surface Waters of the Raritan River Basin including Raritan Bay', effective April 15, 1965.

> Henceforth, industrial wastes prior to discharge into waters of the Raritan River Basin, classified as T.W.-1, shall be treated to a degree providing, as a minimum, eighty percent (80%) of reduction of biochemical oxygen demand at all times and such further reduction of biochemical oxygen demand as may be necessary in order to maintain the waters of the river of a quality as specified by the rules and regulations entitled 'Classification of the Surface Waters of the Raritan River Basin including Raritan Bay', effective April 15, 1965." (A23)

The Wallkill River Basin is covered by the following regulation:

> "Henceforth, industrial wastes (separately or in combination with domestic wastes), prior to discharge into waters of the Wallkill River Basin, classified as F.W.-2 or F.W.-3, shall be treated to a degree providing, as a minimum, ninety-five percent (95%) of reduction of biochemical oxygen demand at all times and such further reduction in biochemical oxygen demand as may be necessary to maintain the receiving waters, after reasonable effluent dispersion, as specified in the rules and regulations entitled 'Regulations Concerning Classification of the Surface Waters of the Wallkill River Basin', effective July 28, 1967; it is an objective of this regulation that the biochemical oxygen demand of effluents discharged shall not exceed fifteen (15) parts per million." (A24)

New Jersey is bounded by the Atlantic Ocean and her east coast is considered as the Atlantic Coastal Plain - here are its discharge regulations:

> "Henceforth, industrial wastes (individually or combined with domestic waste), prior to discharge into waters of the Atlantic Coastal Plain, classified as F.W.-2, F.W.-3, or T.W.-1, shall be treated to a degree providing, as a minimum, ninety-five percent (95%) of reduction of biochemical oxygen demand at all times and such further reduction in biochemical oxygen demand as may be necessary to maintain receiving waters, after reasonable effluent dispersion, as specified in the rules and regulations entitled 'Regulations Concerning Classification of the Surface Waters of the Atlantic Coastal Plain', effective May 24, 1967; it is an objective of this regulation that the biochemical oxygen demand of effluents discharged shall not exceed fifteen (15) parts per million.
>
> Henceforth, industrial wastes prior to discharge into waters of the

> Atlantic Coastal Plain, classified as C.W.-1 and C.W.-2, shall be treated to a degree providing, as a minimum, eighty-five percent (85%) of reduction of biochemical oxygen demand at all times and such further reduction of biochemical oxygen demand as may be necessary in order to maintain the receiving waters in a quality as specified by the rules and regulations entitled 'Classification of the Surface Waters of the Atlantic Coastal Plain', effective May 24, 1967." (A25)

The bulk of New Jersey's Textile Industry is located in the highly industrialized northeastern section of Newark, Paterson, Passaic, Hackensack, Elizabeth City and Jersey City. Most are small (100 employees or less) and use municipal sewers for discharge of effluent. Due to the highly concentrated industry in this area, it is hard to isolate textile wastes, which would lessen the possibility of fines and penalties being administered to individual firms. However, with New Jersey's stipulation for a fixed amount of both percentage removal by weight and volume (parts per million) of B.O.D. allowed in the final effluent, increased control of final discharges will become necessary. It might be well worth their while for New Jersey firms to investigate if pretreatment or full treatment on their effluents will reduce the pollutional load on receiving streams. With tax incentives, they may be able to reduce their sewerage charges and also perform a value service to humanity.

New York

Article 12 of the State Public Health Law is the legislative act that controls water pollution in New York State. The public policy of New York as declared by this act is:

> "to maintain reasonable standards of purity of the waters of the state consistent with public health and public enjoyment thereof, the propagation and protection of fish and wildlife, including birds, mammals and other terrestrial and aquatic life, and the industrial development of the state, and to that end require the use of all known available and reasonable methods to prevent and control the pollution of the waters of the state" (A26).

As of 1961, the duties, powers, authority and functions of water pollution control are vested in the Water Resources Commission under the authority of the State Department of Health. Under this article, the Commissioner of the Department of Health is authorized to: hold public hearings with respect to alleged violations of the pollution control laws; make, modify or cancel orders requiring the discontinuance of the discharge of wastes into state waters and specifying the conditions and time within which such discontinuance must be accomplished; cause to be instituted in a court of competent jurisdiction proceedings to compel compliance with the provisions of the article or his orders; issue, continue, deny, revoke or modify permits for the discharge of wastes, or the installation or operation of disposal systems; and perform such other acts as he may deem necessary and proper to carry out the duties prescribed to him by the article (A26).

The Water Resources Commission has the duty and responsibility to: adopt, amend or cancel such administrative rules and regulations as may be necessary to carry out the provisions of the Article; encourage voluntary cooperation by all persons in preventing the abating pollution of state waters; encourage the formulation and execution of plans by cooperative groups or associations of municipalities, industries, etc., who are or may be the sources of pollution in the same waters, for the prevention and abatement of pollution; cooperate with the appropriate agencies of the United States or other states, or interstate commissions in respect to pollution control matters; conduct studies and research with respect to pollution abatement or control problems; prepare and develop a general comprehensive plan for the abatement of existing pollution and the prevention of new pollution; serve as the agency of the state for the receipt of moneys from the federal government, public or private agencies and to expend said moneys for the purpose of pollution control; require the submission of plans for disposal system construction or reconstruction and to inspect the construction for compliance with approved plans, establish water classification standards; and establish a water quality surveillance network to meet the needs of the state (A26).

The Article has two broad statements of prohibition. It is unlawful for any person to discharge, directly or indirectly, into the waters of the state organic or inorganic matter "that shall cause or contribute to a condition in contravention of the standards adopted by the Water Resources Commission (A). It is also unlawful for any person to make or use a new outlet for the disposal of wastes to waters of the State, to operate or construct disposal systems, or to modify the content of the wastes discharged through permitted outlets, without a valid permit (A26).

For the discharge of all waste effluents, except sanitary sewage, to State waters, efficient removal (75 - 95 percent) of 5-day B. O. D. and suspended solids is required (A27). When plans are submitted to the water resources board for construction of new, or renovation of existing treatment facilities, a description of the waste characteristics and components is required. The biologists in the Conservation Department study each description individually and if it is felt that any of the components would have a detrimental effect on the receiving stream's biota, then the concentration of such components in the waste stream must be limited to the amounts prescribed by such individual study (A28).

(New York)

The State of New York offers two types of tax advantages as incentives for industrial firms to construct their own waste treatment facilities. An income deduction from the State Corporate Income Tax, during the year money is spent, of the cost of wastewater treatment facilities; and an exemption from local taxes and special ad valorem levies for said facilities (A29). These tax advantages are applicable to the following industrial waste water facilities.

"(1) facilities from a point immediately preceding the treatment, neutralization or stabilization device or devices to the point of discharge to the waters of the State, or to a municipal sewer system;

(2) facilities whose primary purpose is pollution abatement even though they may salvage marketable materials;

(3) pretreatment devices which produce an effluent that is in conformance with a municipal sewer use ordinance;

(4) for purposes of State Corporate Income Tax deductions, facilities and pretreatment devices, the construction, reconstruction, erection or improvement of which is initiated on or after January 1, 1965, and only for expenditures paid or incurred prior to January 1, 1972.

(5) for purposes of Real Property Tax exemptions, facilities and pretreatment devices which were constructed or reconstructed subsequent to May 12, 1965 and prior to March 31, 1972. (A30).

The following facilities are ineligible for tax advantages:

"(1) facilities that rely solely upon dilution, dispersion or assimilation of pollutants in the receiving waters;

(2) holding tanks or similar structures unless followed by treatment, neutralization or stabilization;

(3) facilities whose primary purposes are salvage of materials which are usable in the manufacturing process or are marketable;

(4) collection systems including pumping and transmitting facilities preceding the point of treatment, neutralization or stabilization. (A30)"

In order to benefit from these tax deductions, the eligible facilities must possess a certificate compliance. These certificates of compliance are issued by the Department of Health, after the inspection of said facilities proves they are in compliance with the provisions of Article 12, the State Sanitary Code, and regulations, permits or orders issued by the Commissioner of the Department of Health. In the case of pretreatment facilities, the department requires confirmation from the chief administrator of the municipal system to which the industrial effluent is discharged to determine that such facilities were installed pursuant to his approval and that such facilities are producing an effluent which is in conformance with the municipal sewer use ordinance (A30).

For the violation of any provision of Article 12, the discharge of wastes that contravene the standards established by any waters of the state, violation of permit regulations, or the improper operation and maintenance of an approved treatment facility, a person will be served an order to appear at a public hearing before the Commissioner of the Department of Health to answer the charges brought against him. Based on the evidence of such hearing, the Commissioner will give written notice to the alleged violator requiring that the matters complained of be corrected. In the case of a violation that constitutes danger to the health of the people, the Commissioner is authorized to compel the correction of such violation immediately (A26).

For refusing to appear at the above mentioned hearing, or refusing to comply with the written notice from the Commissioner, the Attorney General of the State is empowered to take the alleged violator into a court to face legal proceedings. If convicted, said person shall be guilty of misdemeanor and be fined not less than one hundred dollars, nor more than five hundred dollars and/or imprisoned for a term of not more than one year for each separate violation. Each day of continued violation shall constitute a separate violation (A26). If the alleged violator also possesses a certificate of compliance for tax deduction incentives, the certificate of compliance shall be revoked (A30).

The State of New York has an elaborate set of stream classifications and standards. Table AVI lists the fresh water standards, Table AVII the salt water classifications, and Table AVIII is a compilation of special standards.

(New York)

TABLE AVI. CLASSES AND STANDARDS FOR FRESH WATERS

Class AA

Best Usage of Waters: Source of water supply for drinking, culinary or food processing purposes and any other usages.

Conditions Related to Best Usage: The waters, if subjected to approved disinfection treatment, with additional treatment if necessary to remove naturally present impurities, meet or will meet U. S. Public Health Service drinking water standards and are or will be considered safe and satisfactory for drinking water purposes.

Quality Standards

Items	Specifications
1. Floating solids, settleable solids; oil; sludge deposits; tastes or odor producing substances.	None attributable to sewage, industrial wastes or other wastes.
2. Sewage or wastes effluents.	None which are not effectively disinfected.
3. pH.	Range between 6.5 and 8.5.
4. Dissolved oxygen.	For trout waters, not less than 5.0 parts per million; for non-trout waters, not less than 4.0 parts per million.
5. Toxic wastes, deleterious substances, colored or other wastes or heated liquids.	None alone or in combination with other substances or wastes in sufficient amounts or at such temperatures as to be injurious to fish life, make the waters unsafe or unsuitable as a source of water supply for drinking, culinary or food processing purposes or impair the waters for any other best usage as determined for the specific waters which are assigned to this class.
6. Organisms of coliform group.	Monthly median coliform value shall

Table AVI (Cont'd) (New York)

6. (Cont'd.) Organisms of coliform group.	not exceed 50/100 ml. from a minimum of five examinations and not more than 20 percent of the samples shall exceed a coliform value of 240/100 ml.

NOTE 1: In determining the safety or suitability of waters in this class for use as a source of water supply for drinking, culinary or food processing purposes after approved treatment, the Water Pollution Control Board will be guided by the standards specified in the latest edition of Public Health Service Drinking Water Standards published by the United States Public Health Service.

NOTE 2: With reference to certain toxic substances as affecting fish life, the establishment of any single numerical standard for waters of New York State would be too restrictive. There are many waters, which because of poor buffering capacity and composition will require special study to determine safe concentrations of toxic substances. However, based on non-trout waters of approximately median alkalinity (80 p.p.m.) or above for the state, in which groups most of the waters near industrial areas in this state will fall, and without considering increased or decreased toxicity from possible combinations, the following may be considered as safe stream concentrations for certain substances to comply with the above standard for this type of water. Waters of lower alkalinity must be specially considered since the toxic effect of most pollutants will be greatly increased.

Ammonia or Ammonium Compounds	Not greater than 2.0 parts per million (NH3) at pH of 8.0 or above.
Cyanide	Not greater than 0.1 part per million (CN).
Ferro-or Ferricyanide	Not greater than 0.4 parts per million (Fe(CN)6).
Copper	Not greater than 0.2 parts per million (CU).
Zinc	Not greater than 0.3 parts per million (Zn).

Table AVI (Cont'd.) (New York)

Cadmium	Not greater than 0.3 parts per million (Cd).

Class A

Best Usage of Waters: Source of water supply for drinking, culinary or food processing purposes and any other usages.

Conditions Related to Best Usage: The waters, if subjected to approved treatment equal to coagulation, sedimentation, filtration and disinfection, with additional treatment if necessary to reduce naturally present impurities, meet or will meet U. S. Public Health Service drinking water standards and are or will be considered safe and satisfactory for drinking water purposes.

Quality Standards

Items	Specifications
1. Floating solids; settleable solids; sludge deposits.	None which are readily visible and attributable to sewage, industrial wastes or other wastes or which deleteriously increase the amounts of these constituents in receiving waters after opportunity for reasonable dilution and mixture with the wastes discharged thereto.
2. Sewage or waste effluents.	None which are not effectively disinfected.
3. Odor producing substances contained in sewage, industrial wastes or other wastes.	The waters after opportunity for reasonable dilution and mixture with the wastes discharged thereto shall not have an increased threshold odor number greater than 8, due to such added wastes.
4. Phenolic compounds.	Not greater than 5 parts per billion (Phenol).
5. pH.	Range between 6.5 and 8.5.
6. Dissolved oxygen.	For trout waters, not less than 5.0 parts

Table AVI (Cont'd.) (New York)

6. (Cont'd.) Dissolved oxygen.	per million; for non-trout waters, not less than 4.0 parts per million.
7. Toxic wastes, oil, deleterious substances, colored or other wastes or heated liquids.	None alone or in combination with other substances or wastes in sufficient amounts or at such temperatures as to be injurious to fish life, make the waters unsafe or unsuitable as a source of water supply for drinking, culinary or food processing purposes or impair the waters for any other best usage as determined for the specific waters which are assigned to this class.
8. Organisms of Coliform group.	Monthly median coliform value shall not exceed 5000/100 ml. from a minimum of five examinations and not more than 20 percent of the samples shall exceed a coliform value of 20,000/ml.

Note: Refer to Notes 1 and 2 under Class AA, which are also applicable to Class A standards.

Class B

Best Usage of Waters: Bathing and any other usages except as source of water supply for drinking, culinary or food processing purposes.

Quality Standards

Items	Specifications
1. Floating solids; settleable solids; sludge deposits.	None which are readily visible and attributable to sewage, industrial wastes or other wastes or which deleteriously increase the amounts of these constituents in receiving waters after opportunity for reasonable dilution and mixture with the wastes discharged thereto.

Table AVI (Cont'd.) (New York)

2. Sewage or wastes effluents.	None which are not effectively disinfected.
3. pH.	Range between 6.5 and 8.5.
4. Dissolved oxygen.	For trout waters, not less than 5.0 parts per million; for non-trout waters, not less than 4.0 parts per million.
5. Toxic wastes, oil, deleterious substances, colored or other wastes or heated liquids.	None alone or in combination with other substances or wastes in sufficient amounts or at such temperatures as to be injurious to fish life, make the waters unsafe or unsuitable for bathing or impair the waters for any other best usage as determined for the specific waters which are assigned for this class.
6. Organisms of coliform group.	Monthly median coliform value shall not exceed 2400/100 ml. from a minimum of five examinations and not more than 20 percent of the samples shall exceed a coliform value of 5000/100 ml.

Note: Refer to Note 2 under Class AA, which is also applicable to Class B standards.

Class C

Best Usage of Water: Fishing and any other usages except for bathing as source of water supply for drinking, culinary or food processing purposes.

Quality Standards

Items	Specifications
1. Floating solids; settleable solids; sludge deposits.	None which are readily visible and attributable to sewage, industrial wastes or other wastes or which deleteriously increase the amounts of these constituents in receiving waters after opportunity for reasonable dilution and mixture with the wastes discharged thereto.

2. pH.	Range between 6.5 and 8.5
3. Dissolved oxygen.	For trout waters, not less than 5.0 parts per million; for non-trout waters, not less than 4.0 parts per million.
4. Toxic wastes, oil, deleterious substances, colored or other wastes, or heated liquids.	None alone or in combination with other substances or wastes in sufficient amounts or at such temperatures as to be injurious to fish life or impair the waters for any other best usage as determined for the specific waters which are assigned to this class.

Note: Refer to Note 2 under Class AA, which is also applicable to Class C standards.

Class D

Best Usage of Waters: Agricultural or source of industrial cooling or process water supply and any other except for fishing, bathing or as source of water supply for drinking, culinary or food processing purposes.

Conditions Related to Best Usage: The waters will be suitable for fish survival; the waters without treatment and except for natural impurities which may be present will be satisfactory for agricultural usages or for industrial process cooling water; and with special treatment as may be needed under each particular circumstance, will be satisfactory for other industrial processes.

Quality Standards

Items	Specifications
1. Floating solids, settleable solids; sludge deposits.	None which are readily visible and attributable to sewage, industrial wastes or other wastes or which deleteriously increase the amounts of these constituents in receiving waters after opportunity for reasonable dilution and mixture with the wastes discharged thereto.

Table AVI (Cont'd.) (New York)

2. pH.	Range between 6.0 and 9.5.
3. Dissolved oxygen.	Not less than 3.0 parts per million.
4. Toxic wastes, oil, deleterious substances, colored or other wastes, or heated liquids.	None alone or in combinations with other substances or wastes in sufficient amounts or at such temperatures as to prevent fish survival or impair the waters for agricultural purposes or any other best usage as determined for the specific waters which are assigned to this class.

Note: Refer to Note 2 under Class AA, which is also applicable to Class D standards.

Source: A31 p. 504-507

TABLE AVII. CLASSES AND STANDARDS FOR SALT WATERS

Class SA

Best Usage of Waters: Shellfishing for market purposes and any other usages.

Quality Standards

Items	Specifications
1. Floating solids; settleable solids; oil; sludge deposits.	None attributable to sewage, industrial wastes or other wastes.
2. Garbage, cinders, ashes, oils, sludge or other refuse.	None in any waters of the marine district as defined by State Conservation Law.
3. Sewage or waste effluents.	None which are not effectively disinfected.

Table AVII (Cont'd.) (New York)

4. Dissolved oxygen.	Not less than 5.0 parts per million.
5. Toxic wastes, deleterious substances, colored or other wastes or heated liquids.	None alone or in combination with other substances or wastes in sufficient amounts or at such temperatures as to be injurious to edible fish or shellfish or the culture or propagation thereof, or which in any manner shall adversely affect the flavor, color, odor or sanitary condition thereof or impair the waters for any other best usage as determined for the specific waters which are assigned to this class.
6. Organisms of coliform group.	Median MPN not to exceed 70/100 ml. in any series of samples representative of waters in the shellfish growing area.

Class SB

Best Usage of Waters: Bathing and any other usages except shellfishing for market purposes.

Quality Standards

Items	Specifications
1. Floating solids; settleable solids; oil; sludge deposits.	None attributable to sewage, industrial wastes or other wastes.
2. Garbage, cinders, ashes, oils, sludge or other refuse.	None in any waters of the marine district as defined by State Conservation Law.
3. Sewage or waste effluents .	None which are not effectively disinfected.
4. Dissolved oxygen.	Not less than 5.0 parts per million.
5. Toxic wastes, deleterious substances, colored or other	None alone or in combination with other substances or wastes in sufficient

Table AVII (Cont'd.) (New York)

5. (Cont'd.) wastes or heated liquids.	amounts or at such temperatures as to be injurious to edible fish or shellfish or the culture or propagation thereof, or which in any manner shall adversely affect the flavor, color, odor or sanitary condition thereof; and otherwise none in sufficient amounts to make the waters unsafe or unsuitable for bathing or impair the waters for any other best usage as determined for the specific waters which are assigned for this class.

Class SC

Best Usage of Waters: Fishing and any other usages except bathing or shellfishing for market purposes.

Quality Standards

Items	Specifications
1. Floating solids; settleable solids; sludge deposits.	None which are readily visible and attributable to sewage, industrial wastes or other wastes or which deleteriously increase the amounts of these constituents in receiving waters after opportunity for reasonable dilution and mixture with the wastes discharged thereto.
2. Garbage, cinders, ashes, oils, sludge or other refuse.	None in any waters of the marine district as defined by State Conservation Law.
3. Dissolved oxygen.	Not less than 5.0 parts per million.
4. Toxic wastes, oil, deleterious substances, colored or other wastes or heated liquids.	None alone or in combination with other substances or wastes in sufficient amounts or at such temperatures as to be injurious to edible fish or shellfish, or the culture or propagation thereof, or which in any manner shall adversely

Table AVII (Cont'd.) (New York)

4. (Cont'd.)	affect the flavor, color, odor or sanitary condition thereof or impair the waters for any other best usage as determined for the specific waters which are assigned to this class.

Class SD

Best Usage of Waters: Any usages except fishing, bathing, or shellfishing for market purposes.

Quality Standards

Items	Specifications
1. Floating solids; settleable solids; sludge deposits.	None which are readily visible and attributable to sewage, industrial wastes or other wastes or which deleteriously increase the amounts of these constituents in receiving waters after opportunity for reasonable dilution and mixture with the wastes discharged thereto.
2. Garbage, cinders, ashes, oils, sludge or other refuse.	None in any waters of the marine district as defined by State Conservation Law.
3. Dissolved oxygen.	Not less than 3.0 parts per million.
4. Toxic wastes, oil, deleterious substances, colored or other wastes.	None alone or in combination with other substances or wastes in sufficient amounts to prevent survival of fish life or impair the waters for any other best usage as determined for the specific waters which are assigned to this class.

Source: A31 p. 507-510

TABLE AVIII. SPECIAL CLASSIFICATIONS AND STANDARDS

Class AA - Special Waters

Best Usage of Waters: Any usage except for disposal of sewage, industrial waste or other waste.

Quality Standards

Items	Specifications
1. Floating solids, settleable solids, oil, sludge deposits, toxic wastes, deleterious substances, colored or other wastes or heated liquids.	None attributable to sewage, industrial wastes or other wastes.
2. Sewage or waste effluents.	None into waters of this class.

Class A - Special (International Boundary Waters)

Best Usage of Waters: Source of domestic water supply (when subjected to approved treatment equal to coagulation, sedimentation, filtration and disinfection, with additional treatment if necessary to meet U. S. Public Health Service drinking water standards) or industrial water supply, navigation, fish and wildlife, bathing, recreation, agriculture and other riparian activities.

Quality Standards

Items	Specifications
1. Floating solids; settleable solids; sludge deposits.	None which are readily visible and attributable to sewage, industrial wastes or other wastes or which deleteriously increase the amounts of these constituents in receiving waters after opportunity for reasonable dilution and mixture with the wastes discharged thereto.

Table AVIII (Cont'd.) (New York)

2. Sewage or waste effluents.	None which are not effectively disinfected.
3. Odor producing substances contained in sewage, industrial wastes or other wastes.	The waters after opportunity for reasonable dilution and mixture with the wastes discharged thereto shall not have an increased threshold odor number greater than 8, due to such added wastes.
4. Phenolic compounds.	Not greater than 5 parts per billion (Phenol).
5. pH.	Range between 6.7 and 8.5.
6. Dissolved oxygen.	Not less than 4.0 parts per million.
7. Toxic wastes, oil, deleterious substances, colored or other wastes or heated liquids.	None alone or in combination with other substances or wastes in sufficient amounts or at such temperatures as to adversely affect the usages recognized for this class of waters.

Class I

Best Usage of Waters: Fishing and any other usages except bathing or shellfishing for market purposes.

Quality Standards

Items	Specifications
1. Floating solids; settleable solids; sludge deposits.	None which are readily visible and attributable to sewage, industrial wastes, or other wastes or which deleteriously increase the amounts of these constituents in receiving waters after opportunity for reasonable dilution and mixture with the wastes discharged thereto.
2. Garbage, cinders, ashes, oils, sludge, or other refuse.	None in any waters of the marine district as defined by State Conservation Law.

Table AVIII (Cont'd.) (New York)

3. Sewage or waste effluents.	Effective disinfection if required by International Sanitation Commission.
4. Dissolved oxygen.	An average of not less than 50 percent saturation during any week of the year, but not less than 3.0 parts per million at any time.
5. Toxic wastes, oil, deleterious substances, colored or other wastes or heated liquids.	None alone or in combination with other substances or wastes in sufficient amounts to be injurious to edible fish and shellfish or the culture or propagation thereof, or which shall in any manner affect the flavor, color, odor, or sanitary condition of such fish or shellfish so as to injuriously affect the sale thereof, or which shall cause any injury to the public and private shellfisheries of this state; and otherwise none in sufficient amounts to impair the waters for any other best usage as determined for the specific waters which are assigned to this class.

Class II

Best Usage of Waters: All waters not primarily for recreational purposes, shellfish culture or the development of fish life.

Quality Standards

Items	Specifications
1. Floating solids, settleable solids; sludge deposits.	None which are readily visible and attributable to sewage, industrial wastes or other wastes or which deleteriously increase the amounts of these constituents in receiving waters after opportunity for reasonable dilution and mixture with the wastes discharged thereto.

2. Sewage or waste effluents.	None which are not effectively disinfected.
3. Odor producing substances contained in sewage, industrial wastes or other wastes.	The waters after opportunity for reasonable dilution and mixture with the wastes discharged thereto shall not have an increased threshold odor number greater than 8, due to such added wastes.
4. Phenolic compounds.	Not greater than 5 parts per billion (Phenol).
5. pH.	Range between 6.7 and 8.5.
6. Dissolved oxygen.	Not less than 4.0 parts per million.
7. Toxic wastes, oil, deleterious substances, colored or other wastes or heated liquids.	None alone or in combination with other substances or wastes in sufficient amounts or at such temperatures as to adversely affect the usages recognized for this class of waters.

Class I

Best Usage of Waters: Fishing and any other usages except bathing or shellfishing for market purposes.

Quality Standards

Items	Specifications
1. Floating solids; settleable solids; sludge deposits.	None which are readily visible and attributable to sewage, industrial wastes, or other wastes or which deleteriously increase the amounts of these constituents in receiving waters after opportunity for reasonable dilution and mixture with the wastes discharged thereto.
2. Garbage, cinders, ashes, oils, sludge, or other refuse.	None in any waters of the marine district as defined by State Conservation Law.

Table AVIII (Cont'd.) (New York)

2. Garbage, cinders, ashes, oils, sludge, or other refuse.	None in any waters of the marine district as defined by State Conservation Law.
3. Dissolved oxygen.	An average of not less than 30 percent saturation during any week of the year provided such saturation levels insure adequate oxygen to support fish and shellfish life at all times.
4. Toxic wastes, oil, deleterious substances, colored or other wastes.	None alone or in combination with other substances or wastes in sufficient amounts to be injurious to edible fish and shellfish, or the culture or propagation thereof, or which shall in any manner affect the flavor, color, odor, or sanitary condition of such fish or shellfish so as to injuriously affect the sale thereof, or which shall cause any injury to the public and private shellfisheries of this state.

Source: A31, p. 511-520

These special classes are to be applied to certain drainage areas or particular bodies of water in the state. Class AA-Special is applied to Lake Champlain and the upper Hudson River drainage basin. There are no textile dyeing and finishing firms near the Lake. There are a few textile dyeing and finishing plants located in the latter area; however, they are located in large towns which probably means they use the municipal sewer system.

Classes I and II refer to the waters in and around New York City. There is a large concentration of small to medium textile plants in this area, along with a large population and various other industries. These waters are used for the disposal of treated effluents from New York City's municipal sewer system.

Class A-Special (International Boundary Waters) is applied to those state waters which border on the Dominion of Canada. While no textile dyeing and finishing plants are located on or near the waters so classified, the Water Resources Commission's list of industries producing waste effluents that reduce the dissolved oxygen content of these waters "unreasonably" includes wool scouring (A31).

The textile dyeing and finishing industry in New York is spread throughout the state with a large concentration in the Metropolitan New York City area. The size varies from large to small. Most of the large firms are outside the New York City area but located in large towns, while the bulk of small firms are located in New York City.

Pennsylvania

The "Clean Streams Law" first passed in 1937, and constantly amended, is the water pollution control statute of the Commonwealth of Pennsylvania. The agency which is empowered to enforce this law's provisions is the Sanitary Water Board, a division of the Pennsylvania Department of Health.

The objectives of the act are to prevent the direct discharge of sewage and industrial waste into the streams of the Commonwealth; including those on its borders, and "to restore to a clean state every stream in Pennsylvania that is now polluted." The Sanitary Water Board has two broad powers; the issuance of discharge permits and the setting of treatment standards. Any municipality or person (legal definition) that has an effluent to discharge, must make written application to the Department of Health for a permit. Before the permit is issued, the Sanitary Water Board has the right to inspect the treatment plant and set standards of treatment. Pennsylvania law states that any person or municipality which produces a water waste and discharges this waste to another person or municipality for the purpose of treatment is also responsible for purchasing such a permit.

The penalties imposed for creating pollution, failure to comply with the conditions of an issued permit or failure to provide adequate treatment to wastes are $100-$5,000 fine or imprisonment for one year or both. The $100 fine applies to first offenders, while the $5,000 fine and imprisonment term are for previously convicted offenders if they have not abated pollution practices within two years of first conviction.

The Sanitary Water Board demands at least secondary treatment for all industrial wastes that are bio-degradeable and non-bio-degradeable wastes must receive an equivalent of secondary treatment. The Board further defines secondary treatment as:

> "that treatment that will reduce the organic waste load, as measured by the biochemical oxygen demand test by at least 85% during the period May 1 to October 31 and by at least

> 75% during the remainder of the year based on a five consecutive day average of values; will remove practiccily all of the suspended solids; will provide effective disinfection to control disease producing organisms; will provide satisfactory disposal of sludge; and will reduce the quantities of oils, acids, alkalis, toxic, taste and odor producing substances, color, and other substances inimical to the public interest to levels that will not pollute the receiving stream." (A32)

Pennsylvania's standards have been approved by the Federal Water Pollution Control Administration.

The Commonwealth has set up a complex system of stream classifications. There is a list of "Water Uses" and a list of "Specific Water Quality Criteria" that are used to designate stream standards in the Commonwealth. The twelve sewer basins of Pennsylvania are divided into zones. These zones in some cases pertain to the entire Pennsylvania flow of a creek or stream while in other cases such as the Delaware, Schuylkill, Susquehanna and Monongahela Rivers, the zones are bounded by county, state or municipal lines and confluence of tributaries. Table AIX lists the "Water Uses" specifications and Table AX lists the specific "Water Quality Criteria."

TABLE AIX. WATER USES OF PA. STREAMS

1.0 Aquatic Life

 1.1 Cold Water Fishes - Maintenance and propagation of the family Salmonidae and fish food organisms.

 1.2 Warm Water Fishes - Maintenance and propagation of fish food organisms and all families of fishes except Salmonidae.

 1.3 Migratory Fishes - Passage, maintenance and propagation of anadromous and catadromous fishes, and other fishes which ascend to flowing waters to complete their life cycle.

 1.4 Trout (Stocking Only) - Warm water fishes and trout stocking.

2.0 Water Supply

 2.1 Domestic Water Supply - Use by humans after conventional treat-

Table AIX (Cont'd.) (Pennsylvania)

2.0 Water Supply (Cont'd.)

ment, for drinking, culinary and other purposes.

2.2 Industrial Water Supply - Use by industry for inclusion into products, for processing and for cooling.

2.3 Livestock Water Supply - Use by livestock and poultry for drinking and cleansing.

2.4 Wildlife Water Supply - Use for waterfowl habitat and by wildlife for drinking and cleansing.

2.5 Irrigation Water Supply - Used to supplement precipitation for growing of crops.

3.0 Recreation

3.1 Boating - Power boating, sailboating, canoeing and rowing for recreational purposes.

3.2 Fishing - Use of the water for the taking of fish by legal methods.

3.3 Water Contact Sport - Use of the water for swimming and related activities.

3.4 Natural Area - Use of the water as an esthetic setting to recreational pursuits.

3.5 Conservation Area - Waters used within and suitable for the maintenance of an area now or in the future to be kept in a relatively primitive condition.

4.0 Other

4.1 Power - Use of the water energy to generate power.

4.2 Navigation - Use of the water for the commercial transfer and transport of persons, animals and goods.

4.3 Treated Waste Assimilation - Use of the water for the assimilation and transport of treated waste waters.

Source: A33

(Pennsylvania)

TABLE AX. SPECIFIC WATER QUALITY CRITERIA FOR PA. STREAMS

A. pH

A_1 - Not less than 6.0; not to exceed 8.5

A_2 - Not less than 6.5; not to exceed 8.5

A_3 - Not less than 7.0; not to exceed 9.0

B. Dissolved Oxygen

B_1 - Minimum daily average 6.0 mg./l.; no value less than 5.0 mg./l.

B_2 - Minimum daily average 5.0 mg./l.; no value less than 4.0 mg./l.

B_3 - Minimum daily average not less than 5.0 mg./l., except during the period 4/1 to 6/15 and 9/16 to 12/31, not less than 6.5 mg./l.

B_4 - Minimum daily average not less than 3.5 mg./l., except during the period 4/1 to 6/15 and 9/16 to 12/31, not less than 6.5 mg./l.

B_5 - Minimum daily average not less than 3.5 mg./l., except during period 4/1 to 6/15 and 9/16 to 12/31, not less than 6.5 mg./l.

B_6 - No value less than 7.0 mg./l.

B_7 - For lakes, ponds and impoundments only, no value less than 4.0 mg./l. in the epilimnion.

B_8 - For lakes, ponds and impoundments only, no value less than 5.0 mg./l. at any point.

C. Iron

C_1 - Total iron, not to exceed 1.5 mg./l.

Table AX (Cont'd.) (Pennsylvania)

C_2 - Dissolved iron, not to exceed 0.3 mg./l.

D. Temperature

D_1 - Not to be increased by more than 5° F above natural temperature nor to be increased above 58° F.

D2 - Not to exceed 5° F rise above ambient temperature or a maximum of 87° F, whichever is less; not to be changed by more than 2° F during any one hour period.

D3 - Not to exceed 5° F rise above natural temperature or a maximum of 86° F, whichever is less; not to be changed by more than 2° F during any one hour period.

D4 - Not to exceed 93° F; not to be changed by more than 2° F during any one hour period.

E. Dissolved Solids - Not to exceed 500 mg./l. as a monthly average value; not to exceed 750 mg./l. at any time.

F. Bacteria (Coliforms/100ml. of water)

F_1 - For the period 5/19 to 9/15 of any year, not to exceed 1,000/100 ml. as an arithmetic average value; not to exceed 1,000/100 ml. in more than two consecutive samples; not to exceed 2,400/100 ml. in more than one sample.
For the period 9/16 to 5/14 of any year, not to exceed 5,000/100 ml. as a monthly average value; nor to exceed this number in more than 20% of the samples collected during any month; nor to exceed 2,000/100 ml. in more than 5% of the samples.

F_2 - Not to exceed 5,000/100 ml. as a monthly average value; nor to exceed this number in more than 20% of the samples collected during any month; nor to exceed 20,000/100 ml. in more than 5% of the samples.

F_3 - Not to exceed 5,000/100 ml. as a monthly geometric mean.

Table AX (Cont'd.) (Pennsylvania)

G. Turbidity

G_1 - Not to exceed 30 units during the period 5/30 to 9/15, nor to exceed a monthly mean of 40 units or a maximum of 150 units during the remainder of the year.

G_2 - Maximum monthly mean 40 units, maximum value not to exceed 150 units.

H. Threshold Odor Number - Not to exceed 24 at 60° C.

I. Alkalinity - Not less than 20 mg./l.

J. M.B.A.S. (Methylene Blue Active Substance)

J_1 - Not to exceed 0.5 mg./l.

J_2 - Not to exceed 1.0 mg./l.

K. Total Manganese - Not to exceed 1.0 mg./l.

L. Fluoride - Not to exceed 1.0 mg./l.

M. Cyanide - Not to exceed 0.025 mg./l.

N. Sulfate - Not to exceed 250 mg./l. or natural levels, whichever is greater.

O. Chlorides

O_1 - Not to exceed 150 mg./l.

O_2 - Not to exceed 250 mg./l.

P. Phosphate (total soluable as PO_4)

P_1 - Not to exceed 0.10 mg./l. or natural levels, whichever is greater.

P_2 - Not to exceed 0.30 mg./l. or natural levels, whichever is greater.

P_3 - Not to exceed 0.40 mg./l. or natural levels, whichever is greater.

Table AX (Cont'd.) (Pennsylvania)

Q. Phenol - Not to exceed .005 mg./l.

R. Color - Not to exceed 50 units.

S. Copper

S_1 - Not to exceed 0.02 mg./l.

S_2 - Not to exceed 0.10 mg./l.

T. Zinc - Not to exceed 0.05 mg./l.

Source: A22

At the present time, Pennsylvania does not extend grants to industrial firms for research or offer tax exemptions on treatment facilities. Therefore, firms should try to locate near municipal facilities or expect to finance their own abatement programs completely.

In Pennsylvania, the textile industry is centered in the east, particularly the southeast metropolitan area of Philadelphia; Allentown, Scranton and Reading areas. Most of the firms are small (less than 100 employees) and discharge to municipal sewer systems; however, there are a number of large firms that do exist outside these large population areas and who must supply their own treatment facilities. This fact plus the overworked conditions of the municipal sewers, which could lead to authorities refusing to handle industrial waste loads, encourages the Pennsylvania Textile Industry to study their situation carefully.

Due to the complicated system of stream classification, two firms located on the same river, but in different zones, may find completely different requirements to satisfy. For example, a firm on the Delaware River up stream from Philadelphia may be able to use moderately efficient secondary treatment to render the effluent acceptable to stream standards being the only industrial disposer in the area where the flow volume is large. On the other hand, a firm downstream from Philadelphia would have to take extra care to reduce his effluent due to the wide variety and large volumes of the City's sewage and industrial waste load.

The Southeast

This portion of the United States has become, since the 1950's, the textile manufacturing center of the country. There are six states in this area in which a large number of textile water waste producing firms are located. These States are: Alabama, Georgia, North Carolina, South Carolina, Tennessee and Virginia. No formal interstate compact exists between these states. Alabama, Georgia and Tennessee have similar classification systems, as do North and South Carolina. Virginia is still attempting to receive Federal Water Pollution Control Administration approval for its standards. The laws of the States in this region will be discussed in the following order: Alabama, Georgia, North Carolina, South Carolina, Tennessee and Virginia.

Alabama

The "Alabama Water Pollution Control Act" of 1965 controls water pollution in the state. The purpose of this act is stated as:

> "The improvement and conservation of ground and surface waters of the State of Alabama is of utmost importance. The existing water conditions of the state and the right of municipalities, industries and individuals to the reasonable use of such waters so as to promote the continued growth and development of the state, in industry, agriculture, health, recreation and conservation of natural resources is recognized." (A34)

The Act created a fourteen-member Water Improvement Commission, which is the only state agency with legal responsibilities with respect to water pollution; however, the Commission's authority does not extend to other aspects of water resources. Of the fourteen members appointed to the Commission, one must come from each of the six industrial categories specified by law. One of these categories is the Textile Industry (A35). The Commission is given eight broad powers; they are: to investigate and study all problems concerned with improvement and conservation of the state's waters; to develop programs pertaining to the treatment and disposal of sewage and industrial wastes; to propose remedial measures for the abatement of pollution; insofar as practical means are available, to advise industries and municipalities with respect to the control of pollution; to establish stream standards in relation to their best usage as shall be in the public interest; to receive and examine plans and applications for permits to treat and dispose of sewage and industrial wastes; to investigate the discharge of pollution being made under a permit; and to issue orders directing abatement of pollution within a reasonable specified time.

The Alabama Water Improvement Commission requires the possession of a permit for the discharge of wastes to surface or ground waters in the state. Any person proposing to discharge wastes to said waters must apply to the Commission for a permit and submit such basic information as general description of the proposed operation, the characteristics of the effluents to be discharged, and any other information the

Commission deems necessary. In Alabama, permits are of a permanent nature and are not subject to renewal, although they may be revoked or amended for justifiable cause.

For violation of permit regulations or causing pollution or operating treatment facilities in a manner that threatens potential pollution, a person may be fined not less than one hundred dollars nor more than ten thousand dollars, with each day of continued violation considered a separate offense (A34). The Commission is also given the authority to recover damages for the destruction of wildlife, aquatic life, fish or marine life caused by pollution of state waters (A35).

The Commission requires that:

> "all industrial wastes likely to contain bacteria harmful to humans shall receive a minimum of secondary treatment or the equivalent thereof, and if necessary, disinfection before being discharged to waters of the state used as sources of public water supply, for the harvesting of oysters or customarily used by the public for swimming and other whole body water-contact sports (A36). "

Some industrial waste discharges in Alabama are exempt from this provision of the law because these discharges do not contravene the water quality standards of their receiving waters. However, they will require "a minimum of secondary treatment or its equivalent at such time as plants existing at the time of exclusion must be enlarged or become inadequate for any reason" (A35).

The Commission defines secondary treatment of industrial wastes as "a process or group of processes capable of removing virtually all floating and settleable solids and reduction of 5-day B.O.D. and suspended solids to the minimum extent possible within limits of practicability and technology but not less than 75 percent" (A36). For those industrial wastes "in which B.O.D. and suspended solids are not involved, objectionable constituents shall be controlled, removed or reduced to the maximum degree attainable within the limits of practicability and technology" (A36). The equivalent of secondary treatment is defined as "control and restriction, generally through in-plant measures or storage and regulation of discharge, of waste constituents capable of producing pollutional effects to a degree comparable to that obtained through applicable secondary treatment processes" (A36).

The Commission has designated seven water use classifications and specific water quality criteria for each class (Table AXI). These standards have been approved, with the exceptions of dissolved oxygen and temperature for fish and aquatic life and bacteriological criteria for recreational and potable water supply waters (A35) by the Federal Water Pollution Control Administration.

TABLE AXI. WATER USE CLASSIFICATIONS AND THEIR SPECIFIC WATER QUALITY CRITERIA

PUBLIC WATER SUPPLY

Best Usage of Waters: Source of water supply for drinking or food-processing purposes.

Conditions Related to Best Usage: The waters, if subjected to treatment approved by the State Department of Public Health equal to coagulation, sedimentation, filtration and disinfection, with additional treatment if necessary to remove naturally present impurities and meet the "Public Health Service Drinking Water Standards" will be considered safe for drinking or food-processing purposes.

	Items	Specifications
1.	Sewage, industrial wastes, or other wastes.	None which are not effectively treated or controlled in accordance with Section V of these criteria.
2.	pH.	Sewage, industrial waste or other wastes shall not cause the pH to deviate more than one unit from the normal or natural pH nor be less than 6.0, nor greater than 8.5.
3.	Temperature.	The ambient temperature of receiving waters, in degrees Fahrenheit, after reasonable mixing, shall not be increased by more than 10 percent by the addition of domestic, industrial or other wastes nor shall these wastes cause the temperature of the receiving waters to exceed 90 degrees Fahrenheit, except that the temperature may be as high as 93 degrees Fahrenheit for not more than eight hours

Table AXI (Cont'd.) (Alabama)

3.	Temperature (Cont'd.)	during any twenty-four hour period. With respect to cooling water discharges only, the ambient temperature of receiving waters shall not be increased by more than 10 degrees Fahrenheit by the discharge of such cooling waters, after reasonable mixing; nor shall the discharge of such cooling waters, after reasonable mixing, cause the temperature of the receiving waters to exceed 93 degrees Fahrenheit.
4.	Dissolved oxygen.	Sewage, industrial waste or other wastes shall not cause the dissolved oxygen to be less than 4.0 parts per million as measured at a depth of five feet in waters ten feet or greater in depth and at mid-depth in waters less than ten feet in depth.
5.	Toxic substances; color-producing substances; heated liquids; or other deleterious substances attributable to sewage, industrial wastes or other wastes.	Only such amounts, whether alone or in combination with other substances, and only such temperatures as will not render the waters unsafe or unsuitable as a source of water supply for drinking or food-processing purposes, or injurious to fish, wildlife and aquatic life, or adversely affect the aesthetic value of waters for any use under this classification.
6.	Taste- and odor-producing substances attributable to sewage, industrial wastes, or other wastes.	Only such amounts, whether alone or in combination with other substances or wastes, as will not, cause taste and odor difficulties in water supplies which cannot be corrected by treatment as specified under "Conditions Related to Best Usage", or impair the palatability of fish.
7.	Bacteria.	In the event there are discharges of sewage, or other wastes likely to contain bacteria harmful to humans, to waters within the watershed above the point of

7.	Bacteria (Cont'd.)	taking water for purposes of public water supply or waters for food-processing purposes, after conventional treatment, the following bacteriological criteria are to apply: bacteria of the fecal coliform group not to exceed 5,000 per 100 milliliters (either most probable number of millipore filter count) as a monthly average value; nor exceed this number in more than 20 percent of the samples examined during any month; nor exceed 20,000 per milliliters in more than 5 percent of the samples examined during one month.

NOTE NO. 1: In determining the safety or suitability of waters for use as sources of water supply for drinking or food-processing purposes after approved treatment, the Commission will be guided by the physical and chemical standards specified in the latest edition of the "Public Health Service Drinking Water Standards."

SWIMMING AND OTHER WHOLE BODY-CONTACT SPORTS

Best Usage of Waters: Swimming and other whole body water-contact sports.

Conditions Related to Best Usage: The waters, under proper sanitary supervision by the controlling health authorities, will meet accepted standards of water quality for outdoor swimming places and will be considered satisfactory for swimming and other whole body water-contact sports. The quality of waters will also be suitable for the propagation of fish, wildlife and aquatic life. The quality of salt waters and estuarine waters to which this classification is assigned will be suitable for the propagation and harvesting of shrimp and crabs.

	Items	Specifications
1.	Sewage, industrial wastes, or other wastes.	None which are not effectively treated or controlled in accordance with Section V of these criteria.
2.	pH.	Sewage, industrial wastes or other wastes shall not cause the pH to deviate more than one unit from the normal or natural

Table AXI (Cont'd.) (Alabama)

2.	pH (Cont'd.)	pH nor be less than 6.0 nor greater than 8.5. For estuarine waters and salt waters to which this classification is assigned wastes as described herein shall not cause the pH to deviate more than one unit from the normal or natural pH nor be less than 6.5 nor greater than 8.5.
3.	Temperature.	The ambient temperature of receiving waters, in degrees Fahrenheit, after reasonable mixing, shall not be increased by more than 10 percent by the addition of domestic, industrial or other wastes nor shall these wastes cause the temperature of the receiving waters to exceed 90 degrees Fahrenheit, except that the temperature may be as high as 93 degrees Fahrenheit for not more than eight hours during any twenty-four hour period. With respect to cooling water discharges only, the ambient temperature of receiving waters shall not be increased by more than 10 degrees Fahrenheit by the discharge of such cooling waters, after reasonable mixing; nor shall the discharge of such cooling waters, after reasonable mixing, cause the temperature of the receiving waters to exceed 93 degrees Fahrenheit.
4.	Dissolved oxygen.	Sewage, industrial wastes or other wastes shall not cause the dissolved oxygen to be less than 4.0 parts per million as measured at a depth of five feet in waters ten feet or greater in depth and at mid-depth in waters less than ten feet in depth.
5.	Toxic substances; color-producing substances; odor-producing substances; or other deleterious substances attributable to sewage, industrial wastes	Only such amounts, whether alone or in combination with other substances or wastes, as will not: render the water unsafe or unsuitable for swimming and water-contact sports; be injurious to fish, wildlife and aquatic life or, where applicable,

Table AXI (Cont'd.) (Alabama)

5.	(Cont'd.) or other wastes.	shrimp and crabs; impair the palatability of fish, or, where applicable, shrimp and crabs; impair the waters for any other usage established for this classification or unreasonably affect the aesthetic value of waters for any use under this classification.
6.	Bacteria.	Waters in the immediate vicinity of discharges of sewage or other wastes likely to contain bacteria harmful to humans, regardless of the degree of treatment afforded these waters are not considered acceptable for swimming or other whole body water-contact sports. In the event there are discharges of sewage or other wastes likely to contain bacteria harmful to humans to waters within the watershed above the point of use for swimming and other whole body water-contact sports, the following bacteriological criteria are to apply: bacteria of the fecal coliform group not to exceed 1,000 per 100 milliliters (either most probable number of millipore filter count) as a monthly average value during the months of May through September, nor exceed this value in any two consecutive samples collected during these months. In the event a sanitary survey reveals no discharges of sewage or other wastes likely to contain bacteria harmful to humans within the watershed above the point of use for swimming and other whole body water-contact sports, these bacteriological criteria, at the discretion of the Commission may not apply.

NOTE NO. 2: In assigning this classification to waters intended for swimming and water-contact sports, the Commission will take into consideration the relative proximity of discharges of wastes and will recognize the potential hazards involved in locating swimming areas close

Note No. 2 (Cont'd.) to waste discharges. The Commission will not assign this classification to waters, the bacterial quality of which is dependent upon adequate disinfection of waste and where the interruption of such treatment would render the water unsafe for bathing.

SHELLFISH HARVESTING

Best Usage of Waters: Propagation and harvesting of shellfish for sale or use as a food product.

Conditions Related to Best Usage: Waters will meet the sanitary and bacteriological standards included in the latest edition of the National Shellfish Sanitation Program Manual of Operations, Sanitation of Shellfish Growing Areas; published by the Public Health Service, U. S. Department of Health, Education and Welfare, and the requirements of the State Department of Public Health. The waters will also be a quality suitable for the propagation of fish and other aquatic life, including shrimp and crabs.

	Items	Specifications
1.	Sewage, industrial wastes or other wastes.	None which are not effectively treated in accordance with Section V of these criteria.
2.	pH.	Sewage, industrial wastes or other wastes shall not cause the pH to deviate more than one unit from the normal or natural pH nor be less than 6.5 nor greater than 8.5.
3.	Temperature.	The ambient temperature of receiving waters, in degrees Fahrenheit, after reasonable mixing, shall not be increased by more than 10 percent by the addition of domestic, industrial or other wastes nor shall these wastes cause the temperature of the receiving waters to exceed 90 degrees Fahrenheit, except that the temperature may be as high as 93 degrees Fahrenheit for not more than eight hours during any twenty-four hour period.

Table AXI (Cont'd.) (Alabama)

3.	Temperature (Cont'd.)	With respect to cooling water discharges only, the ambient temperature of receiving waters shall not be increased by more than 10 degrees Fahrenheit by the discharge of such cooling waters, after reasonable mixing; nor shall the discharge of such cooling waters, after reasonable mixing cause the temperature of the receiving waters to exceed 93 degrees Fahrenheit.
4.	Dissolved oxygen.	Sewage, industrial wastes or other wastes shall not cause the dissolved oxygen to be less than 4.0 parts per million as measured at a depth of five feet in waters ten feet or greater in depth and at mid-depth in waters less than ten feet in depth.
5.	Toxic substances attributable to sewage, industrial waste or other wastes.	Only such amounts, whether alone or in combination with other substances, as will not: be injurious to fish and aquatic life including shrimp and crabs; affect the marketability of fish and shellfish, including shrimp and crabs; exceed one-tenth of the 48-hour median tolerance limit for fish, aquatic life or shellfish, including shrimp and crabs.
6.	Color, taste and odor-producing substances and other deleterious substances attributable to sewage, industrial wastes or other wastes.	Only such amounts, whether alone or in combination with other substances, as will not: be injurious to fish and shellfish, including shrimp and crabs; adversely affect marketability or palatability of fish and shellfish, including shrimp and crabs; unreasonably affect the aesthetic value of waters for any use under this classification.
7.	Bacteria.	Not to exceed the limits specified in the latest edition of the National Shellfish Sanitation Program Manual of Operations, Sanitation of Shellfish Growing Areas, published by the Public Health Service, U.S. Dept. of Health, Education and Welfare.

Table AXI (Cont'd.) (Alabama)

FISH AND WILDLIFE

Best Usage of Waters: Fishing, propagation of fish, aquatic life and wildlife and any other usage except for swimming and water-contact sports or as a source of water supply for drinking or food-processing purposes.

Conditions Related to Best Usage: The waters will be suitable for fish aquatic life and wildlife propagation. The quality of salt and estuarine waters to which this classification is assigned will also be suitable for the propagation of shrimp and crabs.

	Items	Specifications
1.	Sewage, industrial wastes or other wastes.	None which are not effectively treated in accordance with Section V of these criteria.
2.	pH.	Sewage, industrial wastes or other wastes shall not cause the pH to deviate more than one unit from the normal or natural pH nor be less than 6.0 nor greater than 8.5. For salt waters and estuarine waters to which this classification is assigned wastes as herein described shall not cause the pH to deviate more than one unit from the normal or natural pH nor be less than 6.5 nor greater than 8.5.
3.	Temperature.	The ambient temperature of receiving waters, in degrees Fahrenheit, after reasonable mixing, shall not be increased by more than 10 percent by the addition of domestic industrial or other wastes nor shall these wastes cause the temperature of the receiving waters to exceed 90 degrees Fahrenheit, except that the temperature may be as high as 93 degrees Fahrenheit for not more than eight hours during any twenty-four hour period. With respect to cooling water discharges

Table AXI (Cont'd.) (Alabama)

3.	Temperature (Cont'd.)	only, the ambient temperature of receiving waters shall not be increased by more than 10 degrees Fahrenheit by the discharge of such cooling waters, after reasonable mixing; nor shall the discharge of such cooling waters, after reasonable mixing, cause the temperature of the receiving waters to exceed 93 degrees Fahrenheit.
4.	Dissolved oxygen.	Sewage, industrial wastes or other wastes shall not cause the dissolved oxygen to be less than 4.0 parts per million as measured at a depth of five feet in water ten feet or greater in depth and at mid-depth in waters less than ten feet in depth.
5.	Toxic substances attributable to sewage, industrial wastes or other wastes.	Only such amounts, whether alone or in combination with other substances, as will not: be injurious to fish and aquatic life including shrimp and crabs in estuarine or salt waters or the propagation thereof; not to exceed one-tenth of the 48 hour median tolerance limit for fish and aquatic life including shrimp and crabs in salt and estuarine waters except that other limiting concentrations may be used when factually justified and approved by the Commission.
6.	Taste, odor and color-producing substances attributable to sewage, industrial waste and other wastes.	Only such amounts, whether alone or in combination with other substances as will not be injurious to fish and aquatic life including shrimp and crabs in estuarine and salt waters or adversely affect the propagation thereof; impair the palatability or marketability of fish and wildlife or shrimp and crabs in estuarine and salt waters; unreasonably affect the aesthetic value of waters for any use under this classification.

Table AXI (Cont'd.)

AGRICULTURAL AND INDUSTRIAL WATER SUPPLY

Best Usage of Waters: Agricultural irrigation, livestock watering, industrial cooling and process water supplies, fish survival and any other usage, except fishing, bathing, recreational activities including water-contact sports or as source of water supply for drinking or food-processing purposes.

Conditions Related to Best Usage: The waters, except for natural impurities which may be present therein, will be suitable for agricultural irrigation, and livestock watering, industrial cooling waters and fish survival. The waters will be usable after special treatment, as may be needed under each particular circumstance, for industrial process water supplies. The waters will also be suitable for other uses for which waters of lower quality will be satisfactory.

	Items	Specifications
1.	Sewage, industrial wastes or other wastes.	None which are not effectively treated or controlled in accordance with Section V of these criteria.
2.	pH.	Sewage, industrial waste or other wastes shall not cause the pH to deviate more than one unit from the normal or natural pH nor be less than 6.0 nor greater than 8.5.
3.	Temperature.	The ambient temperature of receiving waters, in degrees Fahrenheit, after reasonable mixing, shall not be increased by more than 10 percent by the addition of domestic, industrial or other wastes nor shall these wastes cause the temperature of the receiving waters to exceed 90 degrees Fahrenheit, except that the temperature may be as high as 93 degrees Fahrenheit for not more than eight hours during any twenty-four hour period. With respect to cooling water discharges only, the ambient temperature of receiv-

Table AXI (Cont'd.) (Alabama)

3.	Temperature (Cont'd.)	ing waters shall not be increased by more than 10 degrees Fahrenheit by the discharge of such cooling waters, after reasonable mixing; nor shall the discharge of such cooling waters, after reasonable mixing, cause the temperature of the receiving waters to exceed 93 degrees Fahrenheit.
4.	Dissolved Oxygen.	Sewage, industrial waste or other wastes shall not cause the dissolved oxygen to be less than 2.0 parts per million as measured at a depth of five feet in waters ten feet or greater in depth and at mid-depth in waters less than ten feet in depth.
5.	Color, odor-and taste-producing substances, and other deleterious substances, including chemical compounds, attributable to sewage, industrial wastes and other wastes.	Only such amounts as will not render the waters unsuitable for agricultural irrigation, livestock watering, industrial cooling, industrial process water supply and fish survival.

NAVIGATION

Best Usage of Waters: Navigation.

Conditions Related to Best Usage: Waters will be of a quality suitable for navigation and any other uses except agricultural irrigation, livestock watering, industrial cooling, industrial process, water supply, fish and wildlife propagation, recreational activities including swimming and skiing, or source of water supply for drinking or food-processing purposes.

	Items.	Specifications
1.	Sewage, industrial wastes or other wastes.	None which are not effectively treated or controlled to the best practicable degree.
2.	pH.	Sewage, industrial wastes or other wastes shall not cause the normal or natural pH

Table AXI (Cont'd.) (Alabama)

2.	pH (Cont'd.)	to be lower than 5.0 nor greater than 9.5.
3.	Dissolved oxygen.	Sufficient to prevent the development of an offensive condition.
4.	Odor-producing substances.	Only in such amounts as will not create an offensive condition.

TREATED WASTE TRANSPORTATION

Best Usage of Waters: Transportation of sewage, industrial wastes or other wastes which have received the best practicable treatment or control.

Conditions Related to Best Usage: This category includes those watercourses in which natural flow is intermittent and nonexistent during droughts and which must, of necessity, serve as points of disposal of municipal sewage, now and in the future, and of wastes from existing industries. Wastes discharged to these streams must receive the best practicable treatment or control.

	Items	Specifications
1.	Sewage, industrial wastes and other wastes.	None which are not treated or controlled to the best practicable degree.

Source: A36, p. 7-20

These criteria are to be applied to waters which have the appropriate best-use classification. In addition to these specific criteria, the Commission has set the following minimum conditions which are applicable to all state waters:

> "State waters shall be free from substances attributable to sewage, industrial wastes or other wastes that will settle to form bottom deposits which are unsightly, putrescent or interfere directly or indirectly with any classified water use.....or in amounts sufficient to be unsightly or interfere directly or indirectly with any classified water use...or in concentrations or combinations which are toxic or harmful to human, animal or aquatic life" (A36).

(Alabama)

In Alabama, the textile industry is scattered throughout the state, with no particularly heavy concentrations in any one area. Officials in Alabama's Water Improvement Commission feel that the state's textile industries have made outstanding progress in waste treatment (A35). They claim that all major mills have either finished or are in the final stages of having completed construction on treatment facilities. In Alabama, there is an equal division between joint municipal and industrial systems and separate industrial projects.

Georgia

In July 1964, the "Georgia Water Quality Control Act" was passed by the General Assembly of that state. It has had several revisions in 1965 and 1966, but remains unchanged since the latter date. In the act, Georgia has declared as its policy "that the water resources of the state shall be utilized prudently to the maximum benefit of the people in order to restore and maintain a reasonable degree of purity in the waters of the state".

This act also created a Division for Georgia Water Quality Control within the Department of Health; and provided for the setting up of a nine-man State Water Quality Control Board to operate the division and administer the functions granted to it by the Act. In its operation, the Board has light broad powers: to conduct research, in order to determine the value of advanced or new waste treatment processes; to enter into agreements and compacts, with both the Federal and other state governments; to survey state waters, in order to assure pollution is being abated and possibly change a stream's classification; administer and enforce the "Water Quality Control Act" and any other statutes that may be legislated and approved by the General Assembly; to adopt rules and regulations for its conduct of meetings, submission of permit applications, etc.; to make any investigations and inspections that it feels necessary to the abatement of pollution; to establish water quality standards, and to issue orders to prevent a person or municipality found to be polluting state waters from continuing said pollution practices. The Board is also given the power to award grants both from the Federal Water Pollution Control Administration and the State Budget to counties and municipalities and to render any firm, county or municipality laboratory assistance, water quality data, technical and legal advice, etc.

The "Water Quality Control Act" makes it unlawful "to use any waters of the state for the disposal of sewage, industrial wastes, or other wastes", unless they have been rendered by secondary treatment (conventional biological treatment processes) to a degree consistent with the conditions of an issued permit, classification applicable to the receiving stream and the rules and regulations of the Board.

The State of Georgia also defines exactly what the Board is to consider as pollution:

> "'Pollution' means any alteration of the physical, chemical, or biological properties of the waters of this state, including change of temperature, taste, or odor of the waters, or the addition of any liquid, solid, radioactive, gaseous, or other substances to the waters or the removal of such substances from the waters, which will render or is likely to render the waters harmful to the public health, safety, or welfare, or harmful or substantially less useful for domestic, municipal, industrial, agricultural, recreational, or other lawful uses, or for animals, birds, or aquatic life." (A37)

If the Board finds a person or municipality to be causing pollution or a threat of pollution, it has the right to issue, through the superior court of the county in which the violation takes place, an injunction order to cease and desist polluting practices. If a party is found guilty of violating any provision of the Act or does not obey a court injunction order, said party "shall be guilty of a misdemeanor" and is therefore to be punished as provided by law. "Each day of continued violation after conviction shall constitute a separate offense."

There are six "Water Use Classifications" which have been developed by the Georgia Water Quality Control Board. These are: (a) drinking water supplies, (b) recreation, (c) fishing, propagation of fish, shellfish, game and other aquatic life, (d) agricultural, (e) industrial, and (f) navigation.

The State Board of Water Quality Control has promulgated two sets of criteria: "General Criteria for All Waters" (Table AXII), and "Specific Criteria for Classified Water Usage" (Table AXIII). The Board, after surveying the state's waters, classifies a stream according to its use, the streams are classified in decreasing order of quality; that is the best streams are classified as drinking water supplies, while the lowest quality are reserved for navigation. The "General Criteria" must be met by all the waters of the state; however, the stream's classification determines what "Specific Criteria" it must meet. Georgia's standards were approved by the Federal Water Pollution Control Administration on July 19, 1967.

TABLE AXII. GENERAL CRITERIA FOR ALL WATER IN THE STATE OF GEORGIA

(a) All waters shall be free from materials associated with municipal or domestic sewage, industrial waste or any other waste which will settle to form sludge deposits that become putrescent, unsightly or otherwise objectionable.

(b) All waters shall be free from oil, scum and floating debris associated with municipal or domestic sewage, industrial waste or other discharges in amounts sufficient to be unsightly or to interfere with legitimate water uses.

(c) All waters shall be free from material related to municipal, industrial or other discharges which produce turbidity, color, odor or other objectionable conditions which interfere with legitimate water uses.

(d) All waters shall be free from toxic, corrosive, acidic and caustic substances discharged from municipalities, industries or other sources in amounts, concentrations or combinations which are harmful to humans, animals or aquatic life.

(e) The maximum permissible concentration of radio-nuclides in the water of the state must conform to the limits which are cited in Chapter 270, 5-20, "Control of Radio-active Materials", of the Rules and Regulations of the Georgia Department of Public Health.

Source: A38

TABLE AXIII. SPECIFIC CRITERIA FOR CLASSIFIED WATER USAGE IN THE STATE OF GEORGIA

1. Drinking Water Supplies

(a) Those waters approved by the Georgia Department of Public Health and requiring only approved disinfection and meeting the requirements of the latest edition of "Public Health Service Drinking Water Standards"; or waters approved by the Georgia Department of Public Health for human consumption and food processing or for any other use requiring water of a lower quality.

Bacteria	Fecal coliform not to exceed a mean of 50 per 100 milliliters (MPN) based on at

Table AXIII (Cont'd.) (Georgia)

Bacteria (Cont'd.)	least four samples taken over a 30 day period and not to exceed 200 per 100 milliliters in more than five percent (5%) of the samples in any 90 day period.
Floating solids, settleable solids, sludge deposits or any taste, odor or odor producing substances.	None associated with any waste discharge.
Sewage; industrial or other waste	None.

(b) Those raw water supplies requiring approved treatment to meet the requirements of the Georgia Department of Public Health and the latest edition of "Public Health Service Drinking Water Standards" or which are approved by the Georgia Department of Public Health for human consumption and food processing; or for any other use requiring water of a lower quality.

Bacteria	Fecal coliform not to exceed a mean of 5,000 per 100 milliliters (MPN) based on at least four samples taken over a 30 day period and not to exceed 20,000 per 100 milliliters in more than five percent (5%) of the samples taken in any 90 day period.
Dissolved oxygen	Not less than 4.0 milligrams per liter at any time; a minimum of 5.0 milligrams per liter at all times for waters designated as trout streams by the State Game and Fish Commission.
pH	Within the range of 6.0 - 8.5.
Temperature	Not to exceed 93.2°F (34.0°C) at any time and not to be increased more than 10°F above intake temperature. In streams designated as trout waters by the State Game and Fish Commission, there shall be no elevation or depression of natural stream temperatures.

No material or substance in such concentration that, after treatment,

Table AXIII (Cont'd.) (Georgia)

would exceed the requirements of the Georgia Department of Public Health and the latest edition of "Public Health Service Drinking Water Standards."

2. Recreation - General recreation activities such as water skiing, boating and swimming, or for any other use requiring water of a lower quality. These criteria are not to be interpreted as condoning water contact sports in proximity to sewage or industrial waste discharges regardless of treatment requirements imposed on such waters.

Bacteria	Fecal coliform not to exceed a mean of 1,000 per 100 milliliters (MPN) based on at least four samples taken over a 30 day period, and not to exceed 4,000 per 100 milliliters in more than five percent (5%) of samples taken in any 90 day period.
Dissolved oxygen	Not less than 4.0 milligrams per liter except that those streams designated as trout waters by the State Game and Fish Commission must have a minimum of 5.0 milligrams per liter at all times.
pH	Within the range of 6.0 to 8.5.
Toxic wastes and other deleterious materials.	None in concentrations that would harm man, fish and game or other beneficial aquatic life.
Temperature	Not to exceed 93.2°F (34.0°C) at any time and not to be increased more than 10°F above intake temperature. In streams designated as trout waters by the State Game and Fish Commission, there shall be no elevation or depression of natural stream temperatures.

3. Fishing, propagation of fish, shellfish, game and other aquatic life; or any other use requiring water of a lower quality.

Dissolved oxygen	A minimum of 5.0 milligrams per liter at all times for streams designated as trout

Table AXIII (Cont'd.) (Georgia)

Dissolved oxygen (Cont'd.)	waters by the State Game and Fish Commission; a minimum of 4.0 milligrams per liter at all times for waters supporting warm water species of fish.
pH	Within the range of 6.0 to 8.5.
Bacteria	Fecal coliform not to exceed a mean of 5,000 per 100 milliliters (MPN) based on at least four samples taken over a 30 day period and not to exceed 20,000 per 100 milliliters in more than five percent (5%) of the samples in any 90 day period.
Bacteria (Applicable only to shellfish to be commercially harvested)	Total Coliform group not to exceed a median MPN of 70 per 100 milliliters, and not more than 10 percent (10%) of the samples shall exceed an MPN of 230 per 100 milliliters for a 5-tube decimal dilution test (or 330 per 100 milliliters where a 3-tube decimal dilution is used) in those areas most probably exposed to fecal contamination during the most unfavorable hydrographic and pollution conditions.
Temperature	Not to exceed 93.2°F (34.0°C) at any time and not to be increased more than 10°F above intake temperature. In streams designated as trout waters by the State Game and Fish Commission, there shall be no elevation or depression of natural stream temperatures.
Toxic wastes and other deleterious materials	None in concentrations that would harm man, fish and game or other beneficial aquatic life.

4. Agricultural - For general agricultural uses such as stock watering and irrigating; or for any other use requiring water of a lower quality.

Bacteria	Fecal coliform not to exceed a mean of 10,000 per 100 milliliters (MPN) based on

Table AXIII (Cont'd.) (Georgia)

Bacteria (Cont'd.)	at least four samples taken over a 30 day period and not to exceed 40,000 per 100 milliliters in more than five percent (5%) of the samples in any 90 day period.
Dissolved oxygen	A daily average of 3.0 milligrams per liter and no less than 2.5 milligrams per liter at any time.
pH	Within the range of 6.0 to 8.5.
Temperature	Not to exceed 93.2°F (34.0°C) at any time and not to be increased more than 10°F above intake temperature.
Toxic substances and other deleterious materials	None in concentrations or amounts that would interfere with or adversely affect uses for general agricultural purposes or would prevent fish survival.

5. Industrial - For processing and cooling water with or without special treatment; or for any other use requiring water of a lower quality.

Dissolved oxygen	A daily average of 3.0 milligrams per liter and not less than 2.5 milligrams per liter at any time.
pH	Within the range of 6.0 to 8.5.
Toxic substances and other deleterious materials	None in concentrations that would prevent fish survival or interfere with legitimate and beneficial industrial uses.
Temperature	Not to exceed 93.2°F (34.0°C) at any time and not to be increased more than 10°F above intake temperature.

6. Navigation - To provide for commercial ship traffic and protection of seamen or crews.

Bacteria	Fecal coliform not to exceed a mean of 10,000 per 100 milliliters (MPN) based on at least four samples taken over a 30 day period and not to exceed 40,000 per 100 milliliters in more than five percent (5%)

Table AXIII (Cont'd.) (Georgia)

Bacteria (Cont'd.)	of the samples in any 90 day period.
Dissolved oxygen	A daily average of 3.0 milligrams per liter and not less than 2.5 milligrams per liter at any time.
pH	Within the range of 6.0 to 8.5.
Toxic substances, deleterious materials	None in concentrations or amounts that would damage vessels, prevent fish survival or otherwise interfere with commercial navigation.
Temperature	Not to exceed 93.2°F (34.0°C) at any time and not to be increased more than 10°F above intake temperature.

Source: A38

In Georgia, the textile industry is well distributed throughout the state with a concentration of carpet manufacturers in the Dalton area. According to a recent (1966) Georgia Institute of Technology survey (A39), only eight of the forty-eight mills use their own treatment facilities and seven used no treatment at all, while the rest disposed their effluents to city sewers. Due to Georgia's requirement of at least secondary treatment for all wastes, it is likely those seven have now some form of treatment, either municipal or their own. When petitioning the Water Quality Control Board for a permit to treat industrial wastes, besides the engineering diagrams, etc., the plans must also include the following information: type of industry; kind and quantity of finished product; amount of waste and sources; quantity of unpolluted waste water, such as cooling water and provision for separation from other discharges; description of waste including chemical analysis, amount and kinds of chemicals used in process; proposed solution to the problem; cost estimates (operation and maintenance); proficiency and number of personnel needed to assure satisfactory operation and maintenance, and sufficient charts, tables, calculations, basis of design data and graphs to make the report readily understandable. This is required so that when pollution problems exist, the Board can check to see where the load is coming from. Another reason is to enable the Board to lend its assistance to firms of a like nature who wish to locate in Georgia. The State also exempts from ad valorem and poll taxes any equipment used solely for the control of water pollution.

North Carolina

The "North Carolina Water and Air Resources Act" was passed in 1967. This act is the state's water and air pollution control act. It provides for the establishment of a 13 member Board of Water and Air Resources with an auxiliary 9 member Advisory Board, one each for water and air pollution problems. The act also provides for the establishment of water quality standards and the classification of the state's surface waters according to usage. The act empowers the Board to: issue permits for sewage and industrial waste disposal; set water quality standards for each watershed, and to modify these from time to time as the Board sees fit; to conduct hearings; and to provide for the granting of Federal and State funds to municipalities. The Board has empowered itself to lend municipalities, counties and firms trained engineers and chemists to assist in the design, operation and maintenance of waste treatment facilities. The Board's technicians are also available to assist in special studies to determine degree and type of treatment required for a specific effluent.

In the Act, the General Assembly of North Carolina declares as public policy "to provide for the conservation of water and air resources.....to achieve and to maintain for the citizens of the state a total environment of superior quality."

The Board of Water and Air Resources has the responsibility of enforcing compliance to the standards it has set for the various streams in the state. In order to fulfill this obligation, the Board requires sewage plants and individually owned treatment facilities to have a discharge permit and to allow regular routine inspection of its sites by Board engineers and inspectors. If a person or municipality is found to be violating conditions of a permit, causing pollution, or violating any provision of the Water and Air Resources Act, he shall be guilty of a misdemeanor and shall be liable to a penalty of not less than one hundred dollars ($100.00) nor more than one thousand dollars ($1,000.00) for each violation, depending on the seriousness of the violation. Willful violation can be adjudged by the court as a separate violation for each day of violation.

The State of North Carolina requires that all wastes receive the degree of treatment that may be necessary to prevent violation of the assigned classification of the receiving stream. The minimum degree of treatment specified by the Board of Water and Air Resources is secondary treatment (A40).

There are two broad classifications of North Carolina waters: fresh surface and tidal salt waters (defined as "all tidal waters which are so designated by the Board of Water and Air Resources and which generally have a natural chloride ion content in excess of 500 parts per million" (A41). Table I lists the "Fresh Surface Water Classifications and Standards of Water Quality Applied Thereto", and Table II lists the "Tidal Salt Water Classifications and Standards of Water Quality Applied Thereto." These standards have been approved by the Federal Water Pollution Control Administration.

(North Carolina)

TABLE AXIV. FRESH SURFACE WATER CLASSIFICATION AND STANDARDS OF WATER QUALITY APPLIED THERETO

Class A-I:

Best Usage of Waters: Source of water supply for drinking, culinary or food processing purposes or any other usage requiring water of lower quality.

Conditions Related to Best Usage: The waters, if subjected to approved treatment equal to coagulation, sedimentation, filtration and disinfection, with additional treatment if necessary to remove naturally present impurities will meet the "Public Health Service Drinking Water Standards" and will be considered safe for drinking, culinary or food-processing purposes.

Quality Standards for Class A-II Waters:

	Items	Specifications
1.	Floating solids; settleable solids; sludge deposits.	Only such amounts attributable to sewage, industrial wastes or other wastes as will not, after reasonable opportunity for dilution and mixture of same with the receiving waters, make the waters unsafe or unsuitable as a source of water supply for drinking, culinary or food-processing purposes, injurious to fish and wildlife, or impair the waters for any other best usage established for this class.
2.	Sewage, industrial or other wastes.	None which are not effectively treated to the satisfaction of the Board and in accordance with the requirements of the State Board of Health.
3.	Odor-producing substances contained in sewage, industrial or other wastes.	Only such amounts, whether alone or in combination with other substances or wastes, as will not, after reasonable opportunity for dilution and mixture of same with the receiving waters, cause taste and odor difficulties in water supplies which

Table AXIV (Cont'd.) (North Carolina)

3.	Odor-producing (Cont'd.) substances...	cannot be corrected by treatment as specified under "Conditions Related to Best Usage", impair the palatability of fish, or have a deleterious effect upon any best usage established for waters of this class.
4.	Phenolic compounds	Not greater than 3.0 parts per billion (phenols).
5.	pH	Shall be normal for the waters in the area, which generally range between 6.0 and 8.5 except that swamp waters may have a low of 4.3.
6.	Total hardness	Not greater than 100 parts per million as C_aCO_3.
7.	Dissolved oxygen	Not less than 5.0 parts per million for trout producing waters; not less than 4.0 parts per million for non-trout waters except that swamp waters may have a minimum of 3.0 parts per million.
8.	Toxic wastes; oils; deleterious substances; colored or other wastes	Only such amounts, whether alone or in combination with other substances or wastes as will not render the waters unsafe or unsuitable as a source of water supply for drinking, culinary or food-processing purposes, injurious to fish and wildlife or adversely affect the palatability of same, or impair the waters for any other best usage established for this class.
9.	Organisms of coliform group	Not to exceed 5,000/100 milliliters as a monthly average value (either M. P. N. or M. F. count); nor exceed this number in more than 20% of the samples examined during any one month; nor exceed 20,000/100 milliliters in more than five percent (5%) of such samples.
10.	Temperature	Not to exceed 7°F above the ambient

Table AXIV (Cont'd.)   (North Carolina)

10.	Temperature (Cont'd.)	stream or water temperature and in no case to exceed 95°F. The temperature of trout producing waters shall not exceed 70°F due to the discharge of heated liquids.
11.	Radioactive substances	Gross beta activity (in the known absence of Strontium-90 and alpha emitters) not to exceed 1,000 picocuries per liter.

Conditions Related to Best Usage: This class is intended primarily for waters having water sheds which are uninhabited and otherwise protected as required by the State Board of Health and which require only approved disinfection, with additional treatment when necessary to remove naturally present impurities, in order to meet the "Public Health Service Drinking Water Standards" and will be considered safe for drinking, culinary, and food-processing purposes.

Quality Standards for Class A-I Waters:

	Items	Specifications
1.	Floating solids; settleable solids; sludge deposits; taste or odor-producing substances	None attributable to sewage, industrial wastes or other wastes.
2.	Sewage; industrial or other wastes	None.
3.	Toxic wastes; oils; deleterious substances; colored or other wastes.	None.
4.	Organisms of coliform group	Not to exceed 50/100 milliliters (either M. P. N. or M. F. count) as a monthly average value.
5.	Radioactive substances	Gross beta activity (in the known absence of Strontium-90 and alpha emitters) not to exceed 1,000 picocuries per liter at any time.

Table AXIV (Cont'd.) (North Carolina)

NOTE 1: In determining the safety or suitability of waters in this class for use as a source of water supply for drinking, culinary or food-processing purposes after approved disinfection, the Board will be guided by the physical, chemical and bacteriological standards specified in the 1962 edition of the "Public Health Service Drinking Water Standards" and the requirements of the State Board of Health as set forth in Section 5, "Protection of Unfiltered Public Water Supplies", of the Rules and Regulations Providing for the Protection of Public Water Supplies as adopted October 6, 1960 and amended May 9, 1962, August 26, 1965 and October 12, 1967.

Class A-II:

Best Usage of Waters: Source of water supply for drinking, culinary or food-processing purposes and any other best usage requiring waters of lower quality.

NOTE 1: In determining the safety or suitability of waters in this class for use as a source of water supply for drinking, culinary, or food-processing purposes after approved treatment; the Board will be guided by the physical, chemical and bacteriological standards specified in the 1962 edition of the "Public Health Service Drinking Water Standards."

NOTE 2: It is recognized that certain toxic substances will seriously affect fish life; however, the establishment of a single numerical standard for North Carolina waters would be too restrictive. In view of this and since there are many waters which, because of poor buffering capacity and composition will require special consideration, limiting values for such toxic materials will be established on the basis of the characteristics of the particular waters under consideration.

Class B:

Best Usage of Waters: Bathing and any other usage except as source of water supply for drinking, culinary or food-processing purposes.

Conditions Related to Best Usage: The waters, under proper sanitary supervision by the controlling health authorities, will meet accepted standards of water quality for outdoor bathing places and will be considered safe and satisfactory for bathing purposes. Also, suitable for other uses requiring waters of lower quality.

Table AXIV (Cont'd.) (North Carolina)

Quality Standards for Class B Waters:

	Items	Specifications
1.	Floating solids; settleable solids; sludge deposits	Only such amounts attributable to sewage, industrial wastes or other wastes as will not, after reasonable opportunity for dilution and mixture of same with the receiving waters, make the waters unsafe or unsuitable for bathing, injurious to fish and wildlife, or impair the waters for any other best usage established for this class.
2.	Sewage, industrial or other wastes	None which are not effectively treated to the satisfaction of the Board. In determining the degree of treatment required for such waste when discharged into waters to be used for bathing, the Board will take into consideration the quantity and quality of the sewage and wastes involved and the proximity of such discharges to the waters of this class.
3.	Phenolic compounds	Not to exceed 3.0 parts per billion (phenols).
4.	pH	Shall be normal for the waters in the area, which generally range between 6.0 and 8.5, except that swamp waters may have a low of 4.3.
5.	Dissolved oxygen	Not less than 5.0 parts per million for trout producing waters; and not less than 4.0 parts per million for non-trout waters, except that swamp waters may have a minimum of 3.0 parts per million.
6.	Toxic wastes; oils; deleterious substances; colored or other wastes	Only such amounts, whether alone or in combination with other substances or wastes as will not render the waters unsafe or unsuitable for bathing, injurious to fish and wildlife or adversely affect the

Table AXIV (Cont'd.) (North Carolina)

6.	Toxic wastes, etc. (Cont'd.)	palatability of same, or impair the waters for any other best usage established for this class.
7.	Organisms of coliform group (Applicable only during the months of May through September)	Fecal coliform not to exceed an average of 200/100 milliliters (either M. P. N. or M. F. count) based on at least five consecutive samples examined during any 30-day period and not to exceed 400/100 milliliters in more than twenty percent (20%) of the samples, examined during any 30-day period.
8.	Temperature	Not to exceed 7°F above the ambient stream or water temperature, and in no case to exceed 95°F. The temperature of trout producing waters shall not exceed 70°F due to the discharge of heated liquids.

NOTE 1: Refer to Note 2, under Class A-II.

NOTE 2: In assigning this classification to waters intended for bathing, the Board will take into consideration the relative proximity of sources of pollution and will recognize the potential hazards involved in locating swimming areas close to sources of pollution and will not assign this classification to waters, the bacterial quality of which is dependent solely upon adequate disinfection, and where the interruption of such treatment would render the water unsafe for bathing.

Class C:

Best Usage of Waters: Fishing and any other usage except for bathing or as a source of water supply for drinking, culinary or food-processing purposes.

Conditions Related to Best Usage: The waters will be suitable for fish and wildlife propagation; also, suitable for other uses requiring waters of lower quality.

Table AXIV (Cont'd.) (North Carolina)

Quality Standards for Class C Waters:

	Items	Specifications
1.	Floating solids; settleable solids; sludge deposits	Only such amounts attributable to sewage, industrial wastes or other wastes as will not, after reasonable opportunity for dilution and mixture of same with the receiving waters, make the waters unsafe or unsuitable for fish and wildlife, or impair the waters for any other best usage established for this class.
2.	pH	Shall be normal for the waters in the area, which generally range between 6.0 and 8.5, except that swamp waters may have a low of 4.3.
3.	Dissolved oxygen	Not less than 5.0 parts per million for trout producing waters; not less than 4.0 parts per million for non-trout waters, except that swamp waters may have a minimum of 3.0 parts per million.
4.	Toxic wastes; oils; deleterious substances; colored or other wastes	Only such amounts, whether alone or in combination with other substances or wastes as will not render the waters injurious to fish and wildlife or adversely affect the palatability of same, or impair the waters for any other best usage established for this class.
5.	Organisms of coliform group (Applicable only to waters designated by the Board for irrigation of fruits and vegetables.)	Not to exceed an average of 5,000/100 milliliters (either M.P.N. or M. F. count) based on at least five consecutive samples examined during any 30-day period and not to exceed 20,000/100 milliliters in any sample during such period.
6.	Temperature	Not to exceed 7°F above the ambient stream or water temperature and in no case to exceed 95°F. The temperature of

Table AXIV (Cont'd.) (North Carolina)

6.	Temperature (Cont'd.)	trout producing waters shall not exceed 70°F due to the discharge of heated liquids.

NOTE 1: Refer to Note 2, under Class A-II.

Class D:

Best Usage of Waters: Agriculture, industrial cooling and process water supply, fish survival, navigation and any other usage, except fishing, bathing, or as a source of water supply for drinking, culinary or food-processing purposes.

Conditions Related to Best Usage: The waters without treatment and except for natural impurities which may be present therein will be suitable for agricultural uses and will permit fish survival. The waters will also be useable after special treatment by the user as may be needed under each particular circumstance for industrial purposes, including cooling and process waters.

Quality Standards for Class D Waters:

	Items	Specifications
1.	Floating solids; settleable solids; sludge deposits	Only such amounts attributable to sewage, industrial wastes or other wastes as will not, after reasonable opportunity for dilution and mixture of same with the receiving waters render the waters unsuitable for agriculture, industrial cooling purposes and fish survival, or cause an offensive condition.
2.	pH	Shall be normal for the waters in the area, which generally shall range between 6.0 and 8.5, except that swamp waters may have a low of 4.3.
3.	Dissolved oxygen	Not less than 3.0 parts per million.
4.	Toxic wastes; oils; deleterious substances; colored or other wastes	Only such amounts attributable to sewage, industrial wastes or other wastes as will not render the waters unsuitable for agri-

Table AXIV (Cont'd.) (North Carolina)

4.	Toxic wastes, etc. (Cont'd.)	culture, industrial cooling purposes, navigation, and fish survival, or cause offensive conditions.
5.	Organisms of coliform group (Applicable only to waters designated by the Board for irrigation of fruits and vegetables.)	Not to exceed an average of 5,000/100 milliliters (either M. P. N. or M. F. count) based on at least five consecutive samples examined during any 30-day period and not to exceed 20,000/100 milliliters in any sample examined during such period.
6.	Temperature	Not to exceed 7°F above the ambient stream or water temperature, and in no case to exceed 95°F.

NOTE 1: Refer to Note 2, under Class A-II.

Source: A42

TABLE AXV. TIDAL SALT WATER CLASSIFICATIONS AND THE STANDARD OF WATER QUALITY APPLIED THERETO

Class SA:

Best Usage of Waters: Shellfishing for market purposes and any other usage requiring waters of lower quality.

Conditions Related to Best Usage: Waters will meet the sanitary and bacteriological standards given in the 1965 revision of the "National Shellfish Sanitation Program Manual of Operations: Part I, Sanitation of Shellfish Growing Areas", recommended by the Public Health Service and will be considered safe and suitable for shellfish culture.

Quality Standards for Class SA Waters:

	Items	Specifications
1.	Floating solids; settleable solids; sludge deposits	None attributable to sewage, industrial wastes or other wastes.

Table AXV (Cont'd.) (North Carolina)

2.	Sewage, industrial or other wastes	None which are not effectively treated to the satisfaction of the Board and in accordance with the requirements of the State Board of Health.
3.	pH	Range between 6.8 and 8.5.
4.	Dissolved oxygen	Not less than 4.0 parts per million, except that swamp waters may have a minimum of 3.0 parts per million.
5.	Toxic wastes; oils; deleterious substances; colored or other wastes	Only such amounts, whether alone or in combination with other substances or wastes as will not make the waters unsafe or unsuitable for fish and shellfish or their propagation, impair the palatability of same, or impair the waters for any other best usage established for this class.
6.	Organisms of coliform group	Total coliform group not to exceed a median M.P.N. of 70/100 milliliters and not more than 10% of the samples shall exceed an M.P. N. of 230/100 milliliters for a 5-tube decimal dilution test (or 330/100 milliliters where a 3-tube decimal dilution is used) in those areas most probably exposed to fecal contamination during the most unfavorable hydrographic and pollution conditions.
7.	Temperature	Not to exceed 7°F above the ambient stream or water temperature and in no case to exceed 95°F.

NOTE 1: Refer to Note 2, under Class A-II.

Class SB:

Best Usage of Waters: Bathing, and any other usage except shellfishing for market purposes.

Conditions Related to Best Usage: The waters, under proper sanitary super-

Table AXV (Cont'd.) (North Carolina)

Class SB (cont'd)	vision by the controlling health authorities, will meet accepted sanitary standards of water quality for outdoor bathing places and will be considered safe and satisfactory for bathing purposes.

Quality Standards for Class SB Waters:

	Items	Specifications
1.	Floating solids; settleable solids; sludge deposits	None attributable to sewage, industrial wastes or other wastes.
2.	Sewage, industrial or other wastes	None which are not effectively treated to the satisfaction of the Board. In determining the degree of treatment required for such wastes when discharged into waters to be used for bathing, the Board will take into consideration the quantity and quality of the sewage and wastes involved and the proximity of such discharges to the waters in this class.
3.	pH	Shall be normal for the waters in the area, which generally range between 6.0 and 8.5, except that swamp waters may have a low of 4.3.
4.	Dissolved oxygen	Not less than 4.0 parts per million, except that swamp waters may have a minimum of 3.0 parts per million.
5.	Toxic wastes; oils; deleterious substances; colored or other wastes	Only such amounts, whether alone or in combination with other substances or wastes as will not make the waters unsafe or unsuitable for bathing, injurious to fish or shellfish, or adversely affect the palatability of same, or impair the waters for any other best usage established for this class.
6.	Organisms of coliform group (Applicable only during months of May through September)	Fecal coliform not to exceed an average of 200/100 milliliters (either M. P. N. or M. F. count) based on at least five consecutive samples examined during any

Table AXV (Cont'd.) (North Carolina)

6.	Organisms of coliform (Cont'd.)	30-day period and not to exceed 400/100 milliliters in more than twenty percent (20%) of the samples examined during any 30-day period.
7.	Temperature	Not to exceed 7°F above the ambient stream or water temperature, and in no case to exceed 95°F.

NOTE 1: Refer to Note 2, under Class B.

NOTE 2: Refer to Note 2, under Class A-II.

Class SC:

Best Usage of Waters: Fishing, and any other usage except bathing or shellfishing for market purposes.

Conditions Related to Best Usage: The waters will be suitable for fishing and fish propagation. Also, suitable for other uses requiring waters of lower quality.

Quality Standards for Class SC Waters:

	Items	Specifications
1.	Floating solids; settleable solids; sludge deposits	Only such amounts attributable to sewage, industrial wastes or other wastes as will not, after reasonable opportunity for dilution and mixture of same with the receiving waters, make the waters unsafe or unsuitable for fish, shellfish and wildlife, or impair the waters for any other best usage established for this class.
2.	pH	Shall be normal for the waters in the area, which generally range between 6.0 and 8.5, except that swamp waters may have a minimum of 4.3.
3.	Dissolved oxygen	Not less than 4.0 parts per million, except that swamp waters may have a mini-

Table AXV (Cont'd.) (North Carolina)

3.	Dissolved oxygen (cont'd.)	mum of 3.0 parts per million.
4.	Toxic wastes; oils; deleterious substances; colored or other wastes	Only such amounts, whether alone or in combination with other substances or wastes as will not render the waters injurious to fish and shellfish, adversely affect the palatability of same, or impair the waters for any other best usage established for this class.
5.	Organisms of coliform group (Applicable only to waters designated by the Board for irrigation of fruits and vegetables)	Not to exceed an average of 5,000/100 milliliters (either M. P. N. or M. F. count) based on at least five consecutive samples examined during any 30-day period, and not to exceed 20,000/100 milliliters in any sample examined during such period.
6.	Temperature	Not to exceed 7°F above the ambient stream or water temperature, and in no case to exceed 95°F.

NOTE 1: Refer to Note 2, under Class A-II.

Source: A42

North Carolina provides for rapid amortization of industrial waste treatment works, permitting write-off in five years and, in addition, exempts industrial waste treatment facilities from personal property and local ad valorem taxes forever. (A43)

In North Carolina, the textile industry is concentrated in the central portion of the state. No extensive studies concerning textile waste treatment in this state are available. Some large textile operations such as American Enka Corporation in Enka (A44) and Burlington's Cooleemee Plant (A45) have erected their own treatment plants in order for their wastes to be allowed discharge in local streams. In towns such as Greensboro and Kannapolis (A46), there is a mixing of both domestic sewage and industrial waste.

South Carolina

The "South Carolina Pollution Control Law" first passed in 1950 and amended in 1962, 1965 and again in 1969, governs air and water pollution in the State. In passing this law, the General Assembly of South Carolina has declared:

> "to be the public policy of the State that reasonable standards of purity of the waters of the State be maintained, consistent with public health, the public enjoyment of such waters, the propagation and protection of fish, shellfish and wildlife, the operation of existing industries and the future industrial development of the State with a reasonable balance of consideration of the public welfare and, to that end, that the use of reasonable methods to prevent and control pollution of the waters be required." (A47)

The law created within the State Health Department a ten-member Pollution Control Authority of South Carolina. The Authority is empowered to: establish stream use classifications and water quality standards; safeguard the waters of the state from pollution; make, revoke, or modify orders requiring the discontinuance of the discharge of sewage, industrial or other wastes into any waters of the state; institute legal proceedings to compel compliance with the provisions of this Law; issue, continue in effect or deny permits for waste disposal or for the installation or operation of disposal systems; conduct such investigations as it deems advisable and necessary; cooperate with the federal government and other state governments in respect to pollution control matters; conduct research with respect to pollution abatement or control problems; serve as the agency of the state for the receipt of moneys from the federal government or other public or private agencies and expand them for pollution control research or otherwise; and to perform such other and further acts as may be necessary to carry out effectively the duties and responsibilities of the Authority prescribed by this law.

The Authority requires the possession of a permit for the discharge of sewage, industrial or other wastes to streams of the state; and also, for the construction, operation or improvement of new or existing water waste treatment facilities. Any person or municipality found guilty of violating this provision of the law, any other provision of the law or in any way contributing to the pollution of South Carolina rivers and streams, is "guilty of a misdemeanor and upon conviction shall be fined not less than five hundred dollars, nor more than five thousand dollars, or be imprisoned for not more than two years, or both " (A48) with each day's violation to be considered a separate offense. In addition,

> "Any person who discharges organic or inorganic matter into the waters of this State.....to the extent that the fish, shellfish, aquatic animals, wildlife or plant life indigenous to or dependent upon the receiving

> waters are damaged or destroyed shall be liable to the state for a penalty equal to the value of the damage caused, which shall be recovered in a suit brought by the state in its own name or in the name of the Authority.
>
> The amount of any judgment for damages recovered, less cost, shall be remitted to the agency, commission, department or political subdivision of the state that has jurisdiction over the fish, shellfish, aquatic animals, wildlife or plant life damaged or destroyed." (A48)

In classifying the waters of South Carolina, the Pollution Control Authority has established classes for both the fresh surface waters of the state (Table AXVI) and its tidal salt waters (Table AXVII).

TABLE AXVI. ESTABLISHED CLASSES FOR FRESH SURFACE WATERS AND THE STANDARDS OF QUALITY AND PURITY WHICH SHALL BE APPLIED THERETO

Class AA

Waters meeting S. C. State Board of Health requirements as suitable for use for domestic and food processing purposes with disinfection as only treatment required. Suitable also for uses requiring waters of lesser quality.

Quality Standards for Class AA Waters

	Items	Specifications
1.	Sewage or waste effluents.	None.
2.	Dissolved oxygen.	Not less than 5 mg./l.
3.	Toxic wastes, deleterious substances, colored or other wastes.	None in amounts to exceed limitations set forth in the latest edition of U. S. Public Health Service Drinking Water Standards.
4.	Fecal coliform.	Not to exceed 20/100 ml. as a monthly arithmetic average.
5.	Temperature.	Not to exceed 93.2°F at any time, after

Table AXVI (Cont'd.) (South Carolina)

5.	Temperature (cont'd.)	adequate mixing of heated and normal water, as the result of the discharge of heated liquids, nor shall the water temperature in a zone of adequate mixing be more than 10°F greater than that of water unaffected by the heated discharge. PROVIDED: That hydraulic conditions at the point of discharge are arranged so that there is an unheated zone for fish passage between the point of discharge and the zone of adequate mixing.
6.	pH.	Range between 6.0 and 8.0 except that swamp waters may range from pH 5.0 to pH 8.0.

Class A

Waters meeting S. C. State Board of Health requirements as suitable for use as swimming waters. Suitable also for other uses requiring waters of lesser quality.

Quality Standards for Class A Waters

	Items	Specifications
1.	Fecal Coliform.	Not to exceed a geometric mean of 200/100 ml. nor shall more than 10% of the total samples during any 30 day period exceed 400/100 ml.
2.	Phenolic compounds.	Not greater than 1 microgram per liter, unless caused by natural conditions.
3.	pH.	Range between 6.0 and 8.0 except that swamp waters may range from pH 5.0 to pH 8.0.
4.	Dissolved oxygen.	Not less than 5 mg./l., except that swamp waters may have a low of 2.5 mg./l.

Table AXVI (Cont'd.) (South Carolina)

5.	Temperature.	Not to exceed 93.2°F at any time, after adequate mixing of heated and normal water, as the result of the discharge of heated liquids, nor shall the water temperature in a zone of adequate mixing be more than 10°F greater than that of water unaffected by the heated discharge. PROVIDED: That hydraulic conditions at the point of discharge are arranged so that there is an unheated zone for fish passage between the point of discharge and the zone of adequate mixing.

Class B

Waters suitable for domestic supply after complete treatment in accordance with requirements of the S. C. State Board of Health. Suitable also for uses requiring water of lesser quality.

Quality Standards for Class B Waters

	Items	Specifications
1.	Fecal coliform.	Not to exceed 2000/100 ml. as a monthly arithmetic average.
2.	pH.	Range between 6.0 and 8.0, except that swamp waters may range from pH 5.0 to pH 8.0.
3.	Dissolved oxygen.	Not less than 4.0 mg./l. except that swamp waters may have a low of 2.5 mg./l.
4.	Phenolic compounds.	Not greater than 1 microgram per liter unless caused by natural conditions.
5.	Temperature.	Not to exceed 93.2°F at any time, after adequate mixing of heated and normal water, as the result of the discharge of heated liquids, nor shall the water temperature in a zone of adequate mixing be

5.	Temperature (contd.)	more than 10°F greater than that of water unaffected by the heated discharge. PROVIDED: That hydraulic conditions at the point of discharge are arranged so that there is an unheated zone for fish passage between the point of discharge and the zone of adequate mixing.

Class C

Waters suitable for propagation of fish, industrial and agricultural uses and other uses requiring water of lesser quality.

Quality Standards for Class C Waters

	Items	Specifications
1.	pH.	Range between 6.0 and 8.5, except that swamp waters may range between 5.0 and 8.5.
2.	Dissolved oxygen.	Not less than 4 mg./l., except that swamp waters may have a low of 2.5 mg./l.
3.	Temperature.	Not to exceed 93.2°F at any time, after adequate mixing of heated and normal water, as the result of the discharge of heated liquids, nor shall the water temperature in a zone of adequate mixing be more than 10°F greater than that of water unaffected by the heated discharge. PROVIDED: That hydraulic conditions at the point of discharge are arranged so that there is an unheated zone for fish passage between the point of discharge and the zone of adequate mixing.

Class C_a[1]

Waters suitable for fish survival*, industrial and agricultural uses and other uses requiring water of lesser quality.

Quality Standards for Class C_a Waters

	Items	Specifications
1.	pH.	Range between 6.0 and 8.5, except that swamp waters may range between 5.0 and 8.5.
2.	Dissolved oxygen.	Not less than 3.0 mg./l., except that swamp waters may have a low of 2.5 mg./l.
3.	Temperature.	Not to exceed 93.2°F at any time, after adequate mixing of heated and normal water, as the result of the discharge of heated liquids, nor shall the water temperature in a zone of adequate mixing be more than 10°F greater than that of water unaffected by the heated discharge. PROVIDED: That hydraulic conditions at the point of discharge are arranged so that there is an unheated zone for fish passage between the point of discharge and the zone of adequate mixing.

* "Fish Survival" as used in this standard means the continued existence of individual fish normally indigenous to waters of this type.

[1] To apply only to streams receiving waste prior to May 4, 1950, and not to be applied to streams with a 7 day once in 10 years occurrence flow of more than 22.5 mgd.

Source: A49, p. 5-8

(South Carolina)

TABLE AXVII. ESTABLISHED CLASSES FOR TIDAL SALT WATERS AND THE STANDARDS OF QUALITY AND PURITY WHICH SHALL BE APPLIED THERETO

Class SA

Waters suitable for shellfishing for market purposes and any other usages. Suitable also for uses requiring water of lesser quality.

Quality Standards for Class SA Waters

	Items	Specifications
1.	Garbage, cinders, ashes, oils, sludge or other refuse.	None.
2.	Sewage or waste effluents.	None which are not effectively disinfected.
3.	Dissolved oxygen.	Not less than 5.0 mg./l.
4.	Toxic wastes, deleterious substances, colored or other wastes.	None alone or in combination with other substances or wastes in sufficient amounts as to be injurious to edible fish or shellfish or the culture or propagation thereof, or which in any manner shall adversely affect the flavor, color, odor, or sanitary condition thereof or impair the waters for any other best usage as determined for the specific waters which are assigned to this class.
5.	Organisms of coliform group.	Shall meet U. S. Public Health Service Standards (1965 Revision).
6.	pH.	Shall not vary more than 3/10 of a pH unit above or below that of effluent-free waters in the same geographical area having a similar total salinity, alkalinity and temperature.

Table AXVII (Cont'd.) (South Carolina)

7.	Temperature.	Fall, winter, spring, no more than 4°F above natural. Summer, no more than 1.5°F above natural.

Class SB

Waters suitable for bathing and any other usages except shellfishing for market purposes. Suitable also for uses requiring water of less quality.

Quality Standards for Class SB Waters

	Items	Specifications
1.	Garbage, cinders, ashes, oils, sludge or other refuse.	None.
2.	Sewage or waste effluents.	None which are not effectively disinfected.
3.	Dissolved oxygen.	Not less than 5.0 mg./l.
4.	Toxic wastes, deleterious substances, colored or other wastes.	None alone or in combination with other substances or wastes in sufficient amounts as to be injurious to edible fish or the culture or propagation thereof, or which in any manner shall adversely affect the flavor, color, odor or sanitary condition thereof; to make the waters unsafe or unsuitable for bathing or impair the waters for any other best usage as determined for the specific waters which are assigned to this class.
5.	Fecal coliform.	Not to exceed a geometric mean of 200/100 ml. nor shall more than 10% of the samples in any 30 day period exceed 400/100 ml.
6.	pH.	Shall not vary more than one-half of a pH unit above or below that of effluent-free waters in the same geographical area having a similar total salinity, alkalinity,

Table AXVII (Cont'd.) (South Carolina)

6.	pH (Cont'd.)	and temperature, but not lower than 6.75 or above 8.5.
7.	Temperature.	Fall, winter, spring, no more than 4°F above natural. Summer, no more than 1.5°F above natural.

Class SC

Waters suitable for crabbing, commercial fishing and any other usages except bathing or other shellfishing for market purposes. Suitable also for uses requiring water of lesser quality.

Quality Standards for Class SC Waters

	Items	Specifications
1.	Garbage, cinders, ashes, oils, sludge or other refuse.	None.
2.	Dissolved oxygen.	Not less than 4.0 mg./l.
3.	Toxic wastes, oils, deleterious substances, colored or other wastes.	None alone or in combination with other substances or wastes in sufficient amounts as to be injurious to edible fish or the culture or propagation thereof, or which in any manner shall adversely affect the flavor, color, odor, or sanitary condition of fish or impair the waters for any other best usage as determined for the specific waters which are assigned to this class.
4.	Temperature.	Fall, winter, spring, no more than 4°F above natural. Summer, no more than 1.5°F above natural.
5.	pH.	Shall not vary more than one pH unit above or below that of effluent-free waters in the same geographical area having a similar total salinity, alkalinity and temperature but not lower than 6.75 or above 8.5.

Source: A50, p. 1-3

Together with these standards for water quality and purity, South Carolina has a number of general rules which apply to all the waters of the state. They have been established to "maintain in the waters of South Carolina a water quality sufficient for the survival and general well-being of fish and other aquatic life during periods of migration and passage" (A51).

These rules require all bio-degradable waste, prior to discharge to state streams, to receive a minimum of secondary treatment, and all other wastes an equivalent degree of treatment. Another provision of the special rules section is that waters which are subject to effluent discharges and are of a different classification than waters into which they flow, will carry a classification supplemented by the following stipulation: "The quality of any waters receiving sewage, industrial wastes or other waste discharges shall be such that no impairment of the best usage of waters in any other class shall occur by reason of such sewage, or industrial waste discharge" (A51). The general rules also state that "the waters of the state shall at all times be free from:

1. Substances attributable to sewage, industrial waste, or other waste that will settle to form sludge deposits that are unsightly, putrescent or odorous to such degree as to create a nuisance, or that interfere directly or indirectly with water uses;

2. Floating debris, oil, grease, scum, and other floating materials attributable to sewage, industrial waste, or other waste in amounts sufficient to be unsightly to such a degre as to create a nuisance, or that interefere directly or indirectly with water uses;

3. Materials attributable to sewage, industrial waste, or other waste which produce taste, odor, or change the existing color or other physical and chemical conditions in the receiving stream to such a degree as to create a nuisance, or that interfere directly or indirectly with water uses; and

4. High-temperature, toxic, corrosive or other deleterious substances attributable to sewage, industrial waste, or other wastes in concentrations or combinations which interfere directly or indirectly with water uses, or which are harmful to human, animal, plant or aquatic life" (A51).

The State of South Carolina exempts from property taxes any facilities used for pollution control.

(South Carolina)

The Textile Industry is well spread across South Carolina, with a particularly heavy concentration in the vicinity of Greenville. In a comprehensive study on water use, waste treatment and water pollution in South Carolina manufacturing plants, the Water Resources Research Institute of Clemson University (A52) studied the seventy-one textile dyeing and finishing plants in the state. They found that twenty-two firms dispose of their water waste to city sewers, this is particularly true in Greenville and other large cities. Thirty-eight plants provide some form of treatment before final discharge into streams. They found eleven firms that were at that time (1967) not treating their wastes before direct discharge to streams (A52). A list of these firms compiled by the South Carolina Pollution Control Authority, and sent to the above mentioned research organization, showed that nine of the firms were actively engaged in planning to provide for the necessary treatment of their wastes.

Tennessee

The "Tennessee Stream Pollution Control Law" is that state's statute governing the control of water pollution. It was first passed in 1945 and has had several minor revisions. Under the law, the Stream Pollution Control Board was created and instituted as an agency of the State Board of Health. This Pollution Control Board consists of seven members and has the following powers: to exercise general supervision over the administration and enforcement of all laws relating to pollution of the waters of the state; conduct experiments, investigations and research to discover methods of preventing pollution; receive and expend any monies which it may be alloted; issue general orders and adopt rules and regulations for the means of controlling pollution; conduct stream surveys; set, modify and change stream use classifications and water quality standards; enter into agreements with the federal and other state governments to control pollution; and review applications for permits, issue new permits, or modify and revoke existing ones.

For permission to collect, treat and dispose of sewage or industrial wastes in Tennessee, a person or municipality must obtain a permit; a permit is also needed for the right to renovate in any manner existing waste treatment facilities. Each permit issued will stipulate both the conditions under which the discharge may take place and the time during which such discharge may be permitted. The owners of permits must submit reports and records of their operation as deemed necessary by the Public Health Department and allow such inspections and investigations as the Pollution Control Board deems necessary. If the conditions of the permit are found to have been violated, the facility will be given 30 days to take corrective action before the permit is revoked (A53).

If a person or municipality is responsible for causing pollution, they will be required to appear at a hearing before the Pollution Control Board and answer the charges against them. If four or more members of the Board decide that the person is causing pollution, it has the authority to:

> "Issue...special orders (stating generally the nature of conditions to be corrected) directing particular persons responsible for pollution to do or accomplish one or more or all of the following: 1) conduct experiments, investigations and research in order to discover methods and means for controlling pollution; 2) prepare and submit for the approval of the board plans and specifications for streams, facilities, methods and means for controlling pollution; and 3) secure such operating results toward the control of pollution as the board may prescribe." (A54).

If this pollution is adjudged by the Board as constituting "great danger to public health,...the Board shall immediately issue peremptory orders requiring such operating results toward the control of pollution as the Board may prescribe" (A54).

If after the issuance of special or peremptory orders, the person served continues to cause pollution; or if a person operates a treatment facility without permit; or refuses to furnish information, plans or other data, as the Board may require, shall be liable to penalty. The penalty prescribed under law is a fine of not less than fifty dollars, nor more than five hundred dollars for each violation; and each day of continued violation may constitute a separate offense and may subject the system or establishment to abatement as a nuisance (A54).

The Pollution Control Board of Tennessee has adopted a list of five general considerations and seven water-use classifications with a set of criteria for each class (Table AXVIII) "as a guide in determining the permissible conditions of waters with respect to pollution and the prevention or corrective measures required to control pollution in various waters or in different sections of the same waters (A55). These standards and considerations are set on the assumption that:

> "all discharges of sewage, industrial waste, and other wastes will receive the best practicable treatment (secondary or the equivalent) or control according to the policy and procedure of the Tennessee Stream Pollution Control Board. A degree of treatment greater than secondary when necessary to protect the water uses will be required for selected sewage and wastes discharges." (A55)

(Tennessee)

The general considerations are:

"1. Waters have many uses which in the public interest are reasonable and necessary. Such uses include: Sources of water supply for domestic and industrial purposes; propagation and maintenance of fish and other desirable aquatic life; recreational boating and fishing; the final disposal of municipal sewage and industrial waste following adequate treatment; stock watering and irrigation; navigation; generation of power; and the enjoyment of scenic and esthetic qualities of the waters.

2. The rigid application of uniform water quality is not desirable or reasonable because of the varying uses of such waters. The assimilative capacity of a stream for sewage and waste varies depending upon various factors including the following: volume of flow, depth of channel, the presence of falls or rapids, rate of flow, temperature, natural characteristics and the nature of the stream. Also the relative importance assigned to each use will differ for different waters and sections of waters throughout the stream.

3. To permit reasonable and necessary uses of the waters of the State, existing pollution should be corrected as rapidly as practical and future pollution controlled by treatment plants or other measures.

   There is an economical balance between the cost of sewage and waste treatment and the benefits received and within permissible limits the dilution factor and the assimilative capacity of surface water should be utilized. Waste recovery, control of rates and dispersion of waste into the streams, and control of rates and characteristics of flow of waters in the stream where adequate, will be considered to be a means of correction.

4. Sewage, industrial wastes, or other wastes, as defined in the Stream Pollution Control Code, shall not be discharged into or adjacent to streams or other surface waters in such quantity and of such character or under such conditions of discharge in relation to the receiving waters as will result in visual or olfactory nuisances, undue interference to other

reasonable and necessary uses of the water, or appreciable damage to the natural processes of self-purification. In relation to the various qualities and the specific uses of the receiving waters, no sewage, industrial wastes, or other wastes discharged shall be responsible for conditions that fail to meet the criteria of water quality outlined below. Bypassing or accidental spills will not be tolerated.

5. The criteria of water quality are considered as guides in applying the water quality objectives in order to insure reasonable and necessary uses of the waters of the State. In order to protect the public health and maintain the water suitable for other reasonable and necessary uses; to provide for future development; to allow proper sharing of available water resources; and to meet the needs of particular situations additional criteria will be set." (A55)

TABLE AXVIII. CRITERIA OF WATER CONDITIONS

1. Domestic Raw Water Supply

   (a) Dissolved Oyxgen - There shall always be sufficient dissolved oxygen present to prevent odors of decomposition and other offensive conditions.

   (b) pH - The pH value shall lie within the range of 6.0 to 9.0 and shall not fluctuate more than 1.0 unit in this range over a period of 24 hours.

   (c) Hardness or Mineral Compounds - There shall be no substances added to the waters that will increase the hardness or mineral content of the waters to such an extent to appreciably impair the usefulness of the water as a source of domestic water supply.

   (d) Total Dissolved Solids - The total dissolved solids shall at no time exceed 500 mg./l.

   (e) Solids, Floating Materials and Deposits - There shall be no distinctly visible solids, scum, foam, oily sleek, or the formation of slimes, bottom deposits or sludge banks of such size or character as may impair the usefulness of the water as a source of domestic water supply.

   (f) Turbidity or Color - There shall be no turbidity or color added in amounts or characteristics that can not be reduced to acceptable concentrations by conventional water treatment processes.

(g) Temperature - The temperature of the water shall not exceed 93°F and the maximum rate of change shall not exceed 3°F per hour. In no case shall the maximum temperature rise be more than 10°F above the stream temperature which shall be measured at an upstream control point.

(h) Microbiological Coliform - Coliform group shall not exceed 10,000 per 100 ml. as a monthly average value (either MPN or MF count); nor exceed this number in more than 20 percent of the samples examined during any month; nor exceed 20,000 per 100 ml. in more than five percent of such samples. These values may be exceeded provided the organisms are known to be of nonfecal origin. No disease producing bacteria or other objectionable organisms shall be added to surface waters which will result in the contamination of said waters to such an extent as to render the water unsuitable as sources of domestic water supply after conventional water treatment.

(i) Taste or Odor - There shall be no substances added which will result in taste or odor that prevent the production of potable water by conventional water treatment processes.

(j) Toxic Substances - There shall be no toxic substances added to the waters that will produce toxic conditions that materially affect man or animals or impair the safety of a conventionally treated water supply.

(k) Other Pollutants - Other pollutants shall not be added to the water in quantities that may be detrimental to public health or impair the usefulness of the water as a source of domestic water supply.

2. Industrial Water Supply

(a) Dissolved Oxygen - There shall always be sufficient dissolved oxygen present to prevent odors of decomposition and other offensive conditions.

Table AXVIII (Cont'd.) (Tennessee)

(b) pH - The pH value shall lie within the range of 6.0 to 9.0 and shall not fluctuate more than 1.0 unit in this range over a period of 24 hours.

(c) Hardness or Mineral Compounds - There shall be no substances added to the waters that will increase the hardness or mineral content of the waters to such an extent as to appreciably impair the usefulness of the water as a source of industrial water supply.

(d) Total Dissolved Solids - The total dissolved solids shall at no time exceed 500 mg./l.

(e) Solids, Floating Materials and Deposits - There shall be no distinctly visible solids, scum, foam, oily sleek, or the formation of slimes, bottom deposits or sludge banks of such size or character as may impair the usefulness of the water as a source of industrial water supply.

(f) Turbidity or Color - There shall be no turbidity or color added in amounts of characteristics that can not be reduced to acceptable concentrations by conventional water treatment processes.

(g) Temperature - The temperature of the water shall not exceed 93°F and the maximum rate of change shall not exceed 3°F per hour. In no case shall the maximum temperature rise be more than 10°F above the stream temperature which shall be measured at an upstream control point.

(h) Taste or Odor - There shall be no substances added that will result in taste or odor that would prevent the use of the water for industrial processing.

(i) Toxic Substances - There shall be no substances added to the waters that may produce toxic conditions that will adversely affect the water for industrial processing.

(j) Other Pollutants - Other pollutants shall not be added to the waters in quantities that may adversely affect the water for industrial processing.

3. Fish and Aquatic Life

(a) Dissolved Oxygen - The dissolved oxygen shall be maintained at 5.0 mg./l. except in limited sections of the stream receiving treated effluents. In these limited sections, a minimum of 3.0 mg./l. dissolved

(a) oxygen shall be allowed. The dissolved oxygen content shall be measured at mid-depth in waters having a total depth of greater than ten (10) feet. A minimum dissolved oxygen content of 6.0 mg./l. shall be maintained in recognized trout streams.

(b) pH - The pH value shall lie within the range of 6.5 and 8.5 and shall not fluctuate more than 1.0 unit in this range over a period of 24 hours.

(c) Solids, Floating Materials and Deposits - There shall be no distinctly visible solids, scum, foam, oily sleek, or the formation of slimes, bottom deposits or sludge banks of such size or character that may be detrimental to fish and aquatic life.

(d) Turbidity or Color - There shall be no turbidity or color added in such amounts or of such character that will materially affect fish and aquatic life.

(e) Temperature - The temperature of the water shall not exceed 93°F and the maximum rate of change shall not exceed 3°F per hour. The maximum temperature of recognized trout streams shall not exceed 68°F. In no case shall the maximum temperature rise be more than 10°F above the stream temperature which shall be measured at an upstream control point.

(f) Taste or Odor - There shall be no substances added that will impart unpalatable flavor to fish or result in noticeable offensive odors in the vicinity of the water or otherwise interfere with fish or aquatic life.

(g) Toxic Substances - There shall be no substances added to the waters that will produce toxic conditions that affect fish or aquatic life.

(h) Other Pollutants - Other pollutants shall not be added to the waters that will be detrimental to fish or aquatic life.

4. Recreation

(a) Dissolved Oxygen - There shall always be sufficient dissolved oxygen present to prevent odors of decomposition and other offensive conditions.

(b) pH - The pH value shall lie within the range of 6.0 to 9.0 and shall not fluctuate more than 1.0 unit in this range over a period of 24 hours.

(c) Solids, Floating Materials, and Deposits - There shall be no distinctly visible solids, scum, foam, oily sleek, or the formation of slimes, bottom deposits or sludge banks of such size or character that may be detrimental to recreation.

(d) Turbidity or Color - There shall be no turbidity or color added in such amounts or character that will result in an objectionable appearance to the water.

(e) Temperature - The temperature of the water shall not exceed 93°F and the maximum rate of change shall not exceed 3°F per hour. In no case shall the maximum temperature rise more than 10°F above the stream temperature which shall be measured at an upstream control point.

(f) Microbiological Coliform - The fecal coliform group shall not exceed 5,000 per 100 milliliters as a monthly average value nor exceed this number in more than 20 percent of the samples examined during any month; nor exceed 20,000 per 100 milliliters in more than five percent of such samples. In those waters that are physically suitable and available to the public for water-contact recreation the fecal coliform concentration shall not exceed 1,000 per 100 milliliters in any two consecutive samples collected during the months of May through September. Water areas near outfalls of domestic sewage treatment plants are not considered suitable for water-contact recreation.

(g) Taste or Odor - There shall be no substances added that will result in objectionable taste or odor.

(h) Toxic Substances - There shall be no substances added to the water that will produce toxic conditions that affect man or animal.

(i) Other Pollutants - Other pollutants shall not be added to the water in quantities which may have a detrimental effect on recreation.

5. Irrigation

(a) Dissolved Oxygen - There shall always be sufficient dissolved oxygen present to prevent odors of decomposition and other offensive conditions.

(b) pH - The pH value shall lie within the range of 6.0 to 9.0 and shall not fluctuate more than 1.0 unit in this range over a period of 24 hours.

(c) Hardness or Mineral Compounds - There shall be no substances added to the water that will increase the mineral content to such an extent as to impair its use for irrigation.

(d) Solids, Floating Materials and Deposits - There shall be no distinctly visible solids, scum, foam, oily sleek, or the formation of slimes, bottom deposits or sludge banks of such size or character as may impair the usefulness of the water for irrigation purposes.

(e) Temperature - The temperature of the water shall not be raised or lowered to such an extent as to interfere with its use for irrigation purposes.

(f) Toxic Substances - There shall be no substances added to the water that will produce toxic conditions that will affect the water for irrigation.

(g) Other Pollutants - Other pollutants shall not be added to the water in quantities which may be detrimental to the waters used for irrigation.

6. Livestock Watering and Wildlife

(a) Dissolved Oxygen - There shall always be sufficient dissolved oxygen present to prevent odors of decomposition and other offensive conditions.

(b) pH - The pH value shall lie within the range of 6.0 to 9.0 and shall not fluctuate more than 1.0 unit in this range over a period of 24 hours.

(c) Hardness or Mineral Compounds - There shall be no substances added to water that will increase the mineral content to such an extent as to impair its use for livestock watering and wildlife.

(d) Solids, Floating Materials and Deposits - There shall be no distinctly visible solids, scum, foam, oily sleek, or the formation of slimes, bottom deposits or sludge banks of such size or character as to interfere with livestock watering and wildlife.

(e) Temperature - The temperature of the water shall not be raised or lowered to such an extent as to interfere with its use for livestock watering and wildlife.

(f) Toxic Substances - There shall be no substances added to water that will produce toxic conditions that will affect the water for livestock watering and wildlife.

Table AXVIII (Cont'd.) (Tennessee)

(g) Other Pollutants - Other pollutants shall not be added to the water in quantities which may be detrimental to the water for livestock watering and wildlife.

7. Navigation

(a) Dissolved Oxygen - There shall always be sufficient dissolved oxygen present to prevent odors of decomposition and other offensive conditions.

(b) Hardness or Mineral Compounds - There shall be no substances added to the water that will increase the mineral content to such an extent as to impair its use for navigation.

(c) Solids, Floating Materials and Deposits - There shall be no distinctly visible solids, scum, foam, oily sleek, or the formation of slimes, bottom deposits or sludge banks of such size or character as to interfere with navigation.

(d) Temperature - The temperature of the water shall not be raised or lowered to such an extent as to interfere with its use for navigation purposes.

(e) Toxic Substances - There shall be no substances added to water that will produce toxic conditions that will affect the water for navigation.

(f) Other Pollutants - Other pollutants shall not be added to the water in quantities which may be detrimental to the waters used for navigation.

DEFINITIONS

1. Conventional Water Treatment - Conventional water treatment as referred to in the criteria denotes coagulation, sedimentation, filtration and chlorination.

2. Mixing Zone - Mixing zone refers to that section of flowing stream or impounded waters necessary for effluents to become dispersed. The mixing zone necessary in each particular case shall be defined by the Tennessee Stream Pollution Control Board.

Source: A55, p. 2-6

These standards were accepted by the Federal Water Pollution Control Administration in February 1968.

In Tennessee the Textile Industry is located mostly in the eastern part of the state, with a scattering of mills in the central and western parts. Most of the firms are located in towns and municipalities which probably provide them with sewage systems. No indepth study of Tennessee and the textile water waste problem has been undertaken.

Virginia

The "Virginia State Water Control Law" as amended by the 1968 General Assembly governs water pollution in the state. The philosophy of the State concerning water pollution is that existing pollution is to be reduced and potential pollution prevented through control measures. The law establishes a five-member State Water Control Board that is completely independent of all other state agencies. The law empowers the agency to: establish water quality standards; maintain those standards; issue special orders and compel compliance, through the Enforcement Division, to those standards and special orders. The Virginia State Board of Health retains the power of issuing sewage discharge permits and consults and advises waste treatment facility owners (municipal and industrial) on the appropriate treatment required for discharge of their effluent to state streams.

For violation of permit regulations, causing pollution, or violation of any provision of the "Water Control Law", a person or municipality is liable to an injunctive action by the court, to cease polluting practices or fines up to $500 for each separate offense (A).

At present, the stream standards of the Virginia Water Control Board do not satisfy the Federal Water Pollution Control Administration's requirements (A56). The General Assembly of the State has taken action in revising the old law (first passed in 1946) and the Water Control Board has proposed new standards. While these new standards are not yet in effect, they were at the time of writing this report on the Governor's desk awaiting his signature.

The streams of Virginia will be subject to a two-fold classification, each stream is to be assigned a major class and subclass designation. As a minimum, all waters of the State will be satisfactory for fishing and secondary contact recreation. Table AXIX lists the "Major Class" designations to be applied to Virginia waters; Table AXX lists the "Subclasses to Complement Major Water Class Designations."

TABLE AXIX. MAJOR WATER CLASS DESIGNATIONS

Class	Description
I	Open Ocean (Seaside of Land Mass).
II	Estuarine (Tidal Water - Coastal Zone to Fall Line).
III	Free Flowing Streams (Coastal Zone and Piedmont Zone to the Crest of the Mountains).
IV	Mountainous Zone.
V	Put and Take Trout Waters.
VI	Natural Trout Waters.

Standards

Class	Dissolved Oxygen Minimum	Dissolved Oxygen Daily Average	pH	Temperature °F Rise above Natural	Maximum
I	5.0	- -	6.0-8.5	4.0 (Sept.-May) 1.5 (June-Aug.)	--
II	4.0	5.0	6.0-8.5	4.0 (Sept.-May) 1.5 (June-Aug.)	--
III	4.0	5.0	6.0-8.5	5	90
IV	4.0	5.0	6.0-8.5	5	87
V	5.0	6.0	6.0-8.5	--	70
VI	6.0	7.0	6.0-8.5	--	70

Source: A57 : 8

(Virginia)

TABLE AXX. SUBCLASSES TO COMPLEMENT MAJOR WATER CLASS DESIGNATIONS

Subclass A

Description:	Waters generally satisfactory for use as public or municipal water supply, secondary contact recreation, propagation of fish and aquatic life and other beneficial uses.
Standard:	Coliform organisms - Monthly average value not more than 5,000/100 milliliters. (M. P. N. or M. F. count). Not more than 5,000 MPN/100 milliliters in more than 20 percent of the samples in any month. Not more than 20,000/100 milliliters in more than 5 percent of such samples. Fecal coliforms (multiple-tube fermentation or M. F. count) not to exceed a log mean of 1,000/100 milliliters. Not to equal or exceed 2,000/100 milliliters in more than 10 percent of the samples.

Subclass B

Description:	Waters generally satisfactory for use as public or municipal water supply, primary contact recreation (prolonged intimate contact; considerable risk of ingestion), propagation of fish and other aquatic life, and other beneficial uses.
Standard:	Coliform organisms - Monthly average not more than 2,400/100 milliliters. (M. P. N. or M. F. count). Not more than 2,400/100 milliliters in more than 20 percent of the samples in any month. Not applicable during, or immediately following periods of rainfall. Fecal coliforms (multiple-tube fermentation or M. F. count) within a 30-day period not to exceed a log mean of 200/100 ml. Not more than 10 percent of the samples within a 30-day period will exceed 400/100 milliliters.

Subclass C

Description:	Waters satisfactory for use as public or municipal water supply requiring disinfection only.
Standard:	Coliform organisms - Not to exceed 100/100 milliliters (M. P. N. or M. F. count) at any time. No floating or settleable solids, sludge deposits, taste or odor producing substances directly attributable to sew-

Table AXX (Cont'd.) (Virginia)

Standard: age, industrial wastes or other wastes.

Supplement

In open ocean or estuarine waters in the specific areas where leased private or public shellfish beds are present, the following supplement to Subclasses A or B will be applied:

> Not more than 70/100 milliliters of coliform organisms. Not more than 10 percent of the samples ordinarily greater than 230/100 milliliters (5-tube decimal dilution), or 330/100 milliliters (3-tube decimal dilution). Not to be so contaminated by radionuclides, pesticides, herbicides or fecal material so that consumption of the shellfish might be hazardous.

Source: A57, p. 8-9

Two other provisions which relate to all Virginia state waters are:

> "All waters within this state shall at all times be free from all substances attributable to sewage, industrial wastes, or other wastes in concentrations or combinations which contravene established standards or interfere directly or indirectly with beneficial uses of such waters; except that limited zones will be permitted for the mixture of treated sewage, treated industrial wastes, and other waste effluents with receiving waters. The boundaries of mixing zones will be determined on a case by case basis. However, these zones shall generally occupy as small an area and length as possible, and shall not prevent free passage of fish or cause fish mortality.
>
> In lakes and impoundments the temperature of the epilimnion, in those areas where important organisms are most likely to be adversely affected, shall not be raised more than 3°F above that which existed before the addition of heat of artificial origin. The increase is to be based on the monthly average of the maximum daily temperature. Unless a special study shows that a discharge of heated effluent into the hypolim-

> nion (or pumping water from the hypolimnion for discharging back into the same water body) will not produce adverse effects, such practice shall not be approved. Maximum temperatures consistent with the standards established for waters immediately above and below the lake or impoundment will be established for these waters." (A58)

The State requires conventional secondary treatment or its equivalent on sewage and industrial waste before discharge into its streams. With this degree of treatment, the Water Control Board expects to reduce the volume of B.O.D.-5 and suspended solids discharged, to be between 50 and 100 milligrams per liter, depending on the classification and quality standards of the receiving stream. Materials such as: copper, chromium, chlorinated hydrocarbons, phenolic chemicals, toxic materials and water-insoluble organic chemicals must be eliminated from any waste discharges. Color will have to be eliminated, if it causes a nuisance in the receiving stream (A56).

The State grants a five year accelerated amortization of waste treatment or control facilities installed for compliance with State Water Control Law.

The Textile Industry in Virginia is well scattered over the southern portion of the state. For the most part, the individual firms are located in large towns, which would probably have sewage facilities. As to date, there has been no extensive study of Virginia's Textile Industry's water needs and waste treatment problems.

CONCLUSIONS

Each state has established a set of stream standards, which the water pollution control agency of that state is empowered to enforce. The standards applied to a particular stream or portion thereof will determine the degree of treatment required for effluents that are to be discharged into it. A firm located on a stream designated as a source of drinking water supply will have to treat its effluents more effectively than one located on a stream used only as a source of industrial water supply. The first firm would be required to effect higher BOD, dissolved solids and sludge removal than the latter firm.

The stream standards that affect the textile industry the most are: pH, the processes of dyeing, bleaching and adding of certain finishes require aqueous baths of varying alkaline and acid content, therefore, some form of neutralization would be a must to ensure discharges within the range required by stream standards; temperature, the textile industry uses large amounts of water for dyeing and finishing which are heated above 100° F. and such temperatures would contravene any state's standards; color, the dyeing process produces an effluent that imparts an unsightly color to receiving streams; sludge deposits, textile wastes contain inorganic chemicals, bits of fiber and trash that could settle to the bottom of the stream causing objectionable conditions; dissolved oxygen, the organic chemicals used in dyeing and finishing are usually high in BOD, which would lead to the depletion of the stream's dissolved oxygen content; and lastly, toxic materials, a number of chemical finishes and dyes contain chromium and phenolic compounds which are toxic to the aquatic biota.

Each textile water waste producing firm should become familiar with the standards established for the stream into which it is discharging its effluents. These firms would also benefit by working closely with the state water pollution control agency in the event that if standards on treatment requirements are to be changed, they can make the necessary adjustments in the shortest possible time and with the minimum of expense.

Textile firms cannot receive grants-in-aid from the Federal or State governments for the construction or renovation of waste treatment facilities, because the Federal and State grants- in-aid are restricted to municipalities and other political subdivisions. Therefore, they must finance their own waste disposal projects. If this course of action is economically unfeasible, the firm may be able to negotiate with the local sewer authority. Such authority would be able to receive grants-in-aid up to thirty percent of the construction cost, through Section 8 of the Federal Water Pollution Control Act. The firm could offer to pay for a percentage of the remaining costs, thus providing a treatment facility for both the domestic and industrial wastes at a cost to each party that would be less than for the construction of two separate facilities.

The only financial aid available to the industry from the Federal government is for the researching of means to prevent water pollution by industrial wastes and State tax incentives. The Federal research funds can only be used for that purpose; however firms or textile research groups receiving such grants could transfer an equal amount from research funds to treatment facility construction funds. The tax incentives are usually in the form of exemptions and accelerated depreciation; however, all States do not offer such incentives.

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APPENDIX B

ANNOTATED BIBLIOGRAPHY

To supplement the report, an annotated bibliography has been prepared. Most of the references come from the last six years as it was felt this information would be of the greatest use to the reader. As an additional aid the abstracted articles are grouped into eight different sections:

1. General Textile Waste Treatment
2. Cotton Waste Treatment
3. Wool Waste Treatment
4. Man-Made Fiber Waste Treatment
5. Dye Waste Treatment
6. Detergent Waste Treatment
7. Water Treatment for Use
8. Instrumentation and Plant Design for Waste Treatment

While most of the reported articles come under one of the above designations, some can be classed into more than one grouping. The reader is directed to peruse other sections if specific information is not listed under a particular heading.

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GENERAL TEXTILE WASTE TREATMENT

A REVIEW OF THE LITERATURE OF 1968 ON WASTE-WATER AND WATER POLLUTION CONTROL, C. M. Weiss and others; J. Water Pollution Control Fed., 41: 873-1254, (June 1969).

> Literature on analytical methods, wastewater treatment, water pollution, and industrial wastes is reviewed. Of particular interest is the literature review of tannery, textile, and wool scouring wastes.

POLLUTION CONTROL: EVERYONE TO BLAME, T. A. Alspaugh (Cone Mills Corp.); Modern Textiles Mag. 50: 21, 23-24, (Nov. 1969).

> The author reviews the general problem of pollution and emphasizes the need for fundamental research in ecology, chemistry, the effect of pollutants, and other areas. He discusses the use of solvents in sizing, desizing, dyeing, and finishing, and the effects of biodegradability and biochemical oxygen demand on water treatment.

ABSTRACTS OF 1969 ASME/AIChE POLLUTION CONFERENCE. PART 2, Am. Dyestuff Reptr. 58: 31-34, (Aug. 1969).

> Eight papers on various phases of water pollution control are summarized.

CLEANER STREAMS, LOWER COSTS, Textile Inds. 133: 138, 142, 144, 153, (Mar. 1969).

> By 1977, the net waste discharge by the cotton finishing industry is expected to be half the 1963 level as a result of shifts to new processes in finishing plants. Some of the changes that have already been made in desizing, scouring, bleaching, mercerizing, and dyeing are outlined along with factors influencing the waste load and waste treatment costs.

POLLUTION CONTROL EFFORTS: TELL THE WORLD ABOUT IT, Textile Inds. 133: 71-73, (June 1969).

> Proceedings of a symposium on pollution control sponsored jointly by the AATCC and the Departments of Commerce and Interior are summarized. 36 experts from industry and government spoke

on various aspects of the subjects, describing methods of treating wastes efficiently, reporting cost cutting technological developments, and emphasizing the need for greater participation.

FEATURE REPORT: POLLUTION PROBLEMS, Am. Dyestuff Reptr. 58: 11-29, 31, (July 1969).

This report includes 5 articles, some of which are abstracted individually, and summaries of some papers given at the 1969 ASME/AIChE Conference on Stream Pollution Abatement.

USE [illegible] WATER AND DISPOSAL OF EFFLUENT FROM UNDERTAKINGS IN THE TEXTILE INDUSTRY. CONFERENCE OF THE INSTITUTE FOR INDUSTRIAL WATER AND AIR PURIFICATION (Cologne), November 27, HELD AT FRANKFURT/MAIN, Dittrich. Z. ges. Textilind. 71, No. 2: 127-128, (1969), (German) Through World Textile Abstr. 1: 1333, (1969).

Abstracts of the following are given: (1) Practical experience of the Institute for Water and Air Purification in water and effluent problems in textile mills, by H. Fathmann: (2) Advantages and disadvantages of a combined chemical/biological effluent treatment in the textile industry, by H. Jung: (3) Possibilities for the reuse of used water in the factory, by H. Riemer; (4) Costs and fees for the removal of effluent, by W. Gassler (the use of a private treatment and disposal unit is compared in cost with the use of public sewage systems).

WATER POLLUTION CONTROL IN THE TEXTILE INDUSTRY, Textile Chemist & Colorist 1: 171-187, (Mar. 1969).

The following papers, delivered at the AATCC symposium on water pollution control, are published: (1) Better management of water resources is a must if future needs are to be met, by K. L. Kollar (U. S. Dept. of Commerce), p. 171-173: (2) Federal assistance available to companies establishing pollution control programs, by W. J. Lacy and A. Cywin (Fed. Water Pollution Control Admin.), p. 173-176, (3) Treating wastes in a water short area, by D. M. Wells and H. M. Clay, p. 176-179, (4) Research on treatment of dye wastes, by D. L. Michelsen (Va. Polytechnic Inst.), p. 179-181, (5) Water quality management in Virginia, by A. H. Paessler (Va. Water Control Board), p. 181-184, (6) Availability of quality water is important in picking a plant site, by T. A. Fridy (Lockwood Greene Engineers), p. 185-187.

WATER POLLUTION CONTROL IN THE TEXTILE INDUSTRY, Textile Chemist & Colorist 1: 142-157, (Mar. 1969).

> Highlights are given of papers presented at a 2-day symposium sponsored by AATCC's Stream Sanitation Technology Committee in cooperation with the U. S. Departments of Commerce and Interior, held March 1969 in Washington, D.C.: (1) Industry has a poor public image, by R. W. Armstrong; (2) No credit where credit's due, by D. Byrd; (3) (Seven separate papers) What the mills are doing to control water pollution, by B. V. Hill (Am. Enka Corp.), W. I. English (Burlington Inds.), J. L. Brown, Jr. (Cannon Mills), A. L. Smith (Chatham Mfg. Co.), T. A. Alspaugh (Cone Mills), J. C. Pangle, Jr. (Dan River Mills), M. Bright, Jr. (M. Lowenstein & Sons).

MORE PROGRESS NEEDED IN WATER POLLUTION CONTROL, T. A. Alspaugh (Cone Mills Corp.), Am. Textile Reptr. 83: 32-33 (April 1969).

> Proceedings of an AATCC symposium on water pollution control in the textile industry are summarized. The symposium brought together members of the industry and government officials to discuss and review progress made in water pollution control to date and to examine future goals.

POLLUTION CONTROL: INTERVIEW, W. I. English (Burlington Inds.), Modern Textiles Mag. 50: 21-23, (Nov. 1969).

> The techniques being used for treatment of industrial wastes at Burlington Industries are discussed, and the urgent need for more research on the problem of water purification by chemical and biological methods is stressed.

TEXTILE EFFLUENT TREATMENT WITH FLUE GASES, J. S. Franklin, K. Barnes, and A. H. Little; Intern. Dyer 142: 427-432, (Sept. 1969).

> The treatment of waste caustic mercerizing liquors, in a textile factory, utilizing the acidic fractions of boiler flue gases is described. A description of the effluent is given and alternative treatment methods are briefly reviewed. Laboratory work and an indication of the calculations leading to the plant design are included and the installed plant is described. Some operational and performance data are provided, together with an indication of the calculations leading to the plant design are included and the installed plant is described.

TEXTILE WASTES--A BIBLIOGRAPHY, C. D. Livengood; Water Resources Research Inst., N. C. State Univ., P.O. Box 5006, Raleigh, N.C. 27607, (Feb. 1969).

> Abstracts of literature references relative to textile wastes as stream pollutants and published no earlier than 1954 are given. Abstracts from Chemical Abstracts, Textile Technology Digest, Shirley Institute Abstracts, and Water Pollution Abstracts through June 1968 are included. The bibliography is keyword coded and indexed and the abstracts are listed alphabetically by author's last name.

FOR BETTER POLLUTION CONTROL, J. W. Masselli and N. W. Masselli (Wesleyan Univ.), Textile Inds. 133:65-69, (June 1969).

> This is the report of an interview with two chemists at the Wesleyan University's Industrial Waste Laboratory on the problem of stream pollution in the textile industry. Various effluent treatment processes are discussed, and steps in a pollution control program are outlined. Cooperation among industry, government, and the public is urged.

METHODS FOR PROCESSING RESIDUES OBTAINED IN THE PURIFICATION OF TEXTILE EFFLUENTS, J. Rouba; Tech. Wlok. 18, No. 3: 91-95, (1969), (Polish) Through World Textile Abstr. 1: 3220, (1969).

> Physical chemical characteristics of sludges obtained in the purification of textile effluents are outlined and methods of processing are discussed.

STUDY OF FILTRATION OF POST-COAGULATION DEPOSITS FROM TEXTILE MILL EFFLUENT, J. Rouba; Przelad Wlok. 23, No. 6: 301-304, (1969) (Polish) Through World Textile Abstr. 1: 6143, (1969).

> Effluent from the cotton and wool industries has been investigated.

REVIEW OF THE LITERATURE OF 1967 ON WASTE-WATER AND WATER POLLUTION CONTROL, C. M. Weiss and others; J. Water Pollution Control Fed. 40: 897-1219, (June 1968).

> Literature relating to wool and wool scouring wastes, cotton and blends wastes, and synthetic fibers wastes.

EFFLUENT TREATMENT AND WATER CONSERVATION, Intern. Dyer 140: 617, (Nov. 1968).

The following papers presented at the Shirley Institute Conference on Effluent Treatment and Water Conservation are summarized: (1) Treatment of textile wastes in pilot plants, by H. S. Gardner (Shirley Inst.); (2) Activated sludge treatment for waste purification, by J. R. Simpson (Univ. of Newcastle); (3) Water Conservation and future prospects for industrial supplies, by D. H. Newsome (Water Resources Board); (4) Water usage in textile processes, by A. H. Little (Shirley Inst.).

POSSIBILITIES OF BIOLOGICAL PURIFICATION OF TEXTILE EFFLUENT TOGETHER WITH URBAN SEWAGE, J. Debula and A. Nalberczynski; Przeglad Wlok. 22, No. 3: 151-154 (1968), (Polish) Through Shirley Inst. 48: 3591 (1968).

The Biofloc, Turofloc and 'contact stabilization' methods are discussed.

AN ANALYSIS OF TEXTILE WATER WASTES AND A PROCEDURAL FORMAT FOR SOLVING EFFLUENT PROBLEMS, R. D. Elliott; MS Thesis, N. C. State School of Textiles, Raleigh, N. C. (1968).

WATER REQUIREMENTS IN THE TEXTILE INDUSTRY, L. Erbert; Deut. Textiltech. 18, No. 6: 375-380, (1968), (German) Through Shirley Inst. 48: 3715, (1968).

Tables of water consumption are given for the dyeing and finishing of stockings and for finishing processes in the wool and silk industry, and in the finishing of nonwovens.

THE INDUSTRIAL POLLUTION OF WATER, I. THE PROBLEM FACING THE TEXTILE INDUSTRY IN FRANCE, Kamblock, G.; Industrie Text., (France), 963, 825, (1967); Shirley Inst. Abs., 48, 4163, (1968).

II. PURIFICATION TREATMENTS, Industrie Text., (France), 964, 67, (1968); Shirley Inst. 48, 4163, (1968).

III. PURIFICATION TREATMENTS, Industrie Text., (France), 969, 448, (1968); Shirley Inst., 48, 4163, (1968).

A review of textile wastes problems in France and the methods of handling them.

RECLAIMING TEXTILE WASTE WATERS, Pangle, James C., Jr. (Dan River Mills, Inc.), U. S. 3, 419, 493 (CL. 210-44), (31 Dec. 1968), Appl. 22 Dec. 1966; 5pp.

Textile mill waste waters contg. dyes, wetting and scouring agents, caustic soda, and other textile chemicals are reclaimed by the addn. of CaO and CO_2. CaO is added to adsorb impurities followed by settling out as sludge. A gas contg. CO_2 and air aerates the CaO treatment effluent to produce a foam which is removed, broken, and recycled to the waste water. The effluent from the foam treatment is held in a quiescent zone, allowing CO_2 to escape and $CaCO_3$ to ppt. resulting in reclaimed water characterized by a pH of 7-7.5, approx. 30 ppm. Ca, a very low BOD, and a low degree of hardness. The sludge and pptd. CaCO are burned to provide CaO and CO_2 that are recycled to the process.

PROCESS WATER AND PROBLEMS ASSOCIATED WITH TEXTILE EFFLUENT, F. H. Slade; Textile Mfr., 94, p. 14-18, (1968).

Trade effluents contain organic and inorganic substances, and the problems in various sections of industry must be assessed individually to ensure treatment which does not contravene the (British) Public Health Acts or the Rivers (Pollution) Acts. Modern methods and equipment are discussed in this article.

EFFLUENT PROBLEMS AND THEIR SOLUTION, J. J. Priestley; Chem. Process (London) 14, No. 7: 8-11, (1968) Through Chem. Abstr. 69, No. 16: 61398, (1968).

After a brief description of the legislation regarding discharge of trade wastes into public sewers and rivers, the need for a full survey of discharges from all production units including oxidation towers, activated sludge and percolating filters, alkaline textile wastes, acid effluent, steel pickling effluent, and coagulation and sedimentation of suspended solids is discussed.

METHODS FOR PURIFYING TEXTILE EFFLUENTS, J. Rouba; Tech. Wlok. 17, No. 6: 188-190, (1968), (Polish) Through Shirley Inst. 48: 4495, (1968).

Mechanical, chemical, physico-chemical, and biological methods for the treatment of industrial wastes are discussed briefly. In order to reduce the quantity of industrial effluent discharged into reservoirs, the reuse in technological processes of water with a low degree of impurities (a 'closed-circuit' system) is considered.

NOTES ON THE REUSE OF WASTE LIQUORS IN THE PRODUCTION OF TEXTILES, T. Sedzikowski and W. Dobrowolski; Przeglad Wlok. 22, No. 8: 434-436, (1968), (Polish) Through World Textile Abstr. 1: 1956, 1969.

> The reuse of waste liquors carried away into sewage systems of textile mills was studied in order to relieve the shortage of water supplies, and also to comply with general requirements regarding the economy of water. General results of studies carried out at the Textile Research Institute at Lodz are presented with the authors' opinions and suggestions for further work on the topic.

PROCESS WATER AND TEXTILE EFFLUENT PROBLEMS, PART 2., Slade, F. H.; Textile Mfr., 94, p. 89-93 and 99, (1968).

> Biological treatment of effluent, oxygen transfer, continuous sludge removal, flocculation, difficult wastes, and the Lubeck process are considered.

PROCESS WATER AND TEXTILE EFFLUENT PROBLEMS, PART 3, Slade, F. H.; Textile Mfr. 94: 276-281, (July 1968).

> Methods of treatment of dyeing and finishing effluent are described with Joshua Wardle Ltd. (dyes and finishers) as an illustrative example. Effluent treatment plant instrumentation is discussed in terms of pH control and flow control and measurement equipment. Traditional methods of drying sludge (in lagoons) and incineration methods and equipment are considered.

PROCESS WATER AND TEXTILE EFFLUENT PROBLEMS, PART 3, Slade, F. H. Textile Mfr. 94: 224-227, 230, (June 1968).

> Features of plastic filter media, equipment and techniques for treating wool scouring effluent, calcium chloride treatment, and neutralization by boiler flue gases are discussed in this part. 1. ref.

PURIFICATION OF WASTE WATER FROM THE SCOURING OF FABRICS, Antipova, P. S. (VNII VODGEO, Moscow, USSR), Tekst. Prom. (Moscow), (1968), 28 (6), 73, (Russian).

> Waste water from the "Red Rose" hosiery mill contained 260-400 mg./l. anionic and 400-1000 mg./l. nonionic compds. Ca aluminate was used for the treatment and was preprd. in the waste

waters from 50-100 mg./l. $Al_2(SO_4)_3$ (based on the Al) and 1000 mg./l. milk of lime (based on active CaO). If the quantity of anionic compds. was $\geq$ that of the nonionics, then Ca aluminate removed 94-6% of anionics and 55-65% nonionics. An addnl. treatment by flotation was not required.

SEDIMENTATION TANKS AND CLARIFIERS, A. H. Little; Paper Maker: 94, 96, 98, 100-102, (Sept. 1967), Through Shirley Inst. 48: 449, 1968.

Studies in relation to textile trade effluents are described.

ACCELERATED CLARIFICATION OF EFFLUENT, M. R. Tixerant (Water Eng. Ltd.) Intern. Dyer 137: 577-579, (Apr. 1967).

In the Water Engineering Ltd. settling tank sludge settlement is much accelerated and more compact in its settled form over a greatly reduced area. Mechanical clearing of the sludge is dispensed with. Features and action of the WEL tank are described and illustrated with diagrams.

TEXTILE MILL PRODUCTS. Vol. 3. THE COST OF CLEAN WATER, U. S. Dept. of the Interior, Federal Water Pollution Control Admin., (Sept. 1967), Industrial Waste Profiles No. 4.

This volume contains detailed information on processes and wastes, gross waste quantities, waste reduction practices, and cost information in wool textile weaving and finishing and in cotton and synthetic textile finishing.

PROCEEDINGS OF THE SIXTEENTH SOUTHERN WATER RESOURCES AND POLLUTION CONTROL CONFERENCE, Dept. of Civil Eng., Duke Univ., Durham, N. C. (1967).

These conferences are sponsored jointly by Duke University, North Carolina State College, and the University of North Carolina. Included in the proceedings are two papers of specific textile interest: (1) Reuse of plant effluent as process water, by W. J. Day, p. 75-80; and (2) Separation and analysis of color-producing agents in water and wastewater and nonionic exchange resins, by T. F. Walser, p. 81-86. A symposium, by State, on Water resources problems and research needs in the Southeast is also included.

PLASTICS IN WASTE TREATMENT. PART 2., M. W. Askew; Process Biochem. 2, No. 1: 31-34, (1967) Through Chem. Abstr. 66, No. 14: 58697, (1967).

> Pilot-plant studies on textile and resin wastes are noted briefly in a general report on the treatment of effluent. A two-stage treatment over Flocor resulted in 58.0-64.2% BOD removal for textile wastes; for synthetic resins, phenol removal after one stage was 95%.

PLASTICS IN WASTE TREATMENT, Askew, M. W.: Process Biochem., 1, p. 483-486 and 492, 1966; 2, p. 31-34, (1967).

> The author discusses the standards for trade effluent imposed and expected in Europe, Canada and U. S. A. As a result of these higher standards new methods of treatment have been devised using polyvinyl chloride corrugated-sheeting units which can be used in place of established biological filtration media, where cost, space and technical problems make the use of activated-sludge tanks and other conventional methods impracticable. The characteristics of Flocor medium and its advantages over conventional filter media are described and examples are given of its use to treat waste waters from distilleries, breweries fruit and vegetable processing, and textile plants.

BIOLOGICAL TREATMENT OF TEXTILE EFFLUENTS, A. I. Biggs (Confed. of Brit. Ind.), Chem. & Ind., No. 37: 1536-1538, (Sept. 1967).

> The author reviews the research which has been carried out in the field of biological treatment of textile effluents without attempting to deal with the problems of harnessing these results to practical use at individual works.

WATER POLLUTION AND WASTE CONTROL IN THE TEXTILE INDUSTRY, P. Brannock (N. C. State Univ.), Textile Forum 25: 10-13, (Dec. 1967 - Jan. 1968).

> The treatment and disposal of textile effluents in North Carolina are briefly surveyed under the following headings: Evaluation of the pollution problem; Sources and types of textile process wastes; Characteristics and effects of pollution; Determination of a course of action; and Reduction of wastes by in-plant process control.

SIMPLIFIED CHEMICAL TREATMENT OF WASTE WATER FROM TEXTILE FACTORIES WITH CLARIFYING, FLOCCULATING, AND PRECIPITATING AGENTS, Dietrich, W. R.; Text.-PRAX., 22, (2), p. 126-127, (1967), (German).

> Mixtures of electrolytes containing Al^{3+}, Fe^{3+}, Fe^{++}, Si^{4+}, and Ca^{++} are more effective flocculating agents than those containing only Fe^{3+} cations. Applied to textile plant sewage at < 50 mg./l., the mixtures drastically reduce the organic matter, ppt. or absorb dyes and P compounds, and improve the drying of the sludge; the effects are largely independent of pH.

WATER RESOURCES GUIDE FOR TEXTILES, T. E. Elders; Master's Thesis, Georgia Inst. of Technol., Atlanta, Ga., (1967), 102 p.

> Suggestions, data, and general directions to assist the textile industry in solving water problems are discussed under the following headings: legal stipulations, water supply, water purification, waste water treatment, and in-plant modification.

EXPERIENCE IN DECONTAMINATION OF EFFLUENTS FROM THE RODNIKOVSKY SPINNING MILL, Krasovskii, L. V.: Gig. Sanit., 32, (7), p. 98-99, (1967), (Russian).

> A table is given showing the change in color, ph, suspended solids, BOD, etc., produced by a purification plant involving said traps, settling basins, and aero-tanks. The coli-index required chlorination and a graph of residual Cl vs. dosage is included. Promising redns. of coli-index and no. of colonies were obtained with irradn. by using a low-pressure Ar-Hg lamp.

MECHANICAL TREATMENT OF EFFLUENT, Krasovskii, L. V.; Tekstil. Prom., 27, (10, p. 61-62, (1967), (Russian).

> The use of screens, sand traps, and settling tanks in the treatment of textile-processing effluent containing fibre, bits of fabric, insoluble particles of dye, and chemical auxiliaries is discussed.

TREATMENT OF TEXTILE WASTE LIQUORS, A. H. Little (Shirley Inst.), J. Soc. Dyers Colourists 83: 268-273, (July 1967).

> The character of textile waste liquors, the estimation of organic load in waste liquors, treatment methods, water reuse, and analytical effluent tests are examined in this paper.

THE USE OF WEAK-ACID CATIONIC AGENTS TO REMOVE ZINC FROM HIGHLY MINERALIZED WASTE WATERS, V. K. Marinich, N. L. Shevchenko, and O. V. Firsova; Khim. Volok, No. 2: 63-65, (1967), (Russian) Through Shirley Inst. 47: 2485, (1967).

> Zinc compounds can be almost completely removed from waste waters with the aid of weak-acid cationic agents KB-4 and KB-4P-2. On average, the consumption of agents normally used in effluent purification (soda, caustic soda) is reduced by 30%, the method is less cumbersome in application, and less equipment and plant is required. The method is suitable for the removal of zinc from highly mineralized effluent from viscose cord and staple fiber production.

TEXTILE WATER POLLUTION CLEANUP PICKS UP SPEED, Pinault, R. W.; Textile World, 117, p. 52-66, (1967).

> The problem of textile water pollution and what government regulations mean to the textile manufacturer are examined. Factors to be considered in the selection of an effluent treatment system are discussed and case studies of the waste treatment plants now in use at five different textile mills are cited.

EFFECT OF INDUSTRIAL WASTEWATERS ON THE HORIZON OF FERRUGINOUS ACCUMULATION OF NORTHWESTERN MESHCHERA SOILS, V. S. Shishova and V. T. Dodolina; Kokl. TSKhA No. 124: 85-93, (1967) Through Chem. Abstr. 68: 8312, 1968.

> Laboratory experiments were carried out to determine the effect on soil samples of wastewaters from a textile factory and a pharmaceutical plant that contain large amounts of inorganic salts and that are used for spray irrigation. It was found that the alkaline wastewaters reduced the acidity of ferruginous soil samples and did not cause leaching of the iron; in humus soils, the amounts of alkaline earth elements and organic substances were reduced.

PURIFICATION OF WASTE WATER IN THE TEXTILE INDUSTRY, C. Strugaru and G. Cristescu; Industria Textila 18, No. 12: 743-746, (1967), (Rumanian) Through Shirley Inst. 48: 994, 1968.

> Problems of the treatment of textile effluent prior to its discharge into a municipal drainage system are discussed.

EFFLUENT PROBLEMS AND THEIR TREATMENT IN THE TEXTILE INDUSTRY, T. H. Summers (Nalfloc Ltd.), J. Soc. Dyers Colourists 83: 373-379, (Sept. 1967).

> Textile effluent problems and treatment in the U. K. are discussed under the following headings: legislative progression, textile industry effluents, determination of effluent characteristics, methods for resolving effluent problems, principles of treatment, neutralization of effluents, synthetic detergents, color, bleachery wastes, and future trends.

WATER AND EFFLUENTS, R. W. Moncrieff; Textile Mfr. 93: 11-13, (Jan. 1967).

> Lectures presented at a half-day symposium by the London Region of the Soc. of Dyers & Colourists on Nov. 4, 1966 are summarized:
> (1) Water for the dyehouse, by T. H. Morton
> (2) Water usage in rinsing, by G. J. Parish
> (3) Surface active agents in processes and effluents, by W. V. Barnes and S. Dobson
> (4) Treatment of effluents, by A. H. Little

TREATMENT AND DISPOSAL OF THE SLUDGE IN WASTE-WATER TREATMENTS, Vogel, W.; Milliand Textilber., 48, (8), p. 950-954, (1967), (German).

> Sludge from textile effluent has a high water content, and before disposal must be treated to separate this water. Equipment for various methods of sludge treatment is reviewed. The methods include rotting and stabilizing, static and dynamic water separation, drying, combustion, and conversion to compost.

WATER POLLUTION: CHALLENGE TO INDUSTRIAL LEADERSHIP, L. [illegible]. Jones, Jr. (Canton Textiles Inc.), Textile Bull. 92: 68-69, (Mar. 1966).

> Industrial responsibility for effective pollution control is emphasized.

ELECTRIC FLOTATION OF SUSPENDED PARTICLES WITH THE USE OF FLOTATION REAGENTS, B. M. Matov; Elektron. Obrab. Mater., Akad. Nauk Mold. SSR No. 3: 80-82, (1966), (Russian).

> Waste water from a silk production plant has been clarified by flotation of suspended particles in an electric field. Various flotation reagents were used; optimum conditions were obtained with 0.4 g/l of ferric chloride.

PRESENT STATUS OF INDUSTRIAL WASTE-WATER TREATMENT INSTALLATIONS, G. Pais, R. Mitroiu, and H. Weinberg; Hidrotch. Gospodarirea Apelor Meterol. 11, No. 3: 149-155, (1966), (Rumanian).

> Figures for silk and wool industries are included in analytical data (pH values, total suspensions, and organic matter) on waste waters from various industries. Methods of waste water treatment are also discussed.

TEXTILE INDUSTRY WARS ON STREAM WASTE POLLUTION: AN STN INDUSTRY SURVEY, Allen, F.: Southern Textile News, 22, p. 1, 2, 10, 11, (Aug. 1966).

> Textile industry efforts to combat stream waste pollution are illustrated with specific examples.

BIOLOGICAL WASTE TREATMENT SYSTEMS, Dravo Corp., Water & Waste Treatment Dept., 1 Oliver Plaza, Pittsburgh, Pa. 15222, (1969), 12 p.

> Features of various Dravo biological waste treatment systems are described, and textile applications are indicated.

PROCEEDINGS OF THE FIFTEENTH SOUTHERN WATER RESOURCES AND POLLUTION CONTROL CONFERENCE, Dept. of Civil Eng., N. C. State Univ., Raleigh, N. C. (1966).

> These conferences are sponsored jointly by Duke University, North Carolina State University, and the University of North Carolina. Included in the proceedings are two papers of specific textile interest: (1) Applicability of optimization techniques to textile mill waste treatment, by J. M. DeBruhl and C. Smallwood, Jr., p. 63-80; (2) Recoverable warp sizes, by R. N. Berrier and H. Y. Jennings, p. 81-83.

SYMPOSIUM ON WASTE-DISPOSAL PROBLEMS OF SOUTHERN MILLS, Am. Dyestuff Reptr., 44 (12), p. 279-400, (1966).

> Papers on Relation of Federal stream pollution to laws and industry; Cotton slashing with synthetic compounds as means toward pollution abatement; Bleaching and dyehouse waste studies; Textile waste treatment in Texas; Biological treatment of mixture of highly alkaline textile-mill waste and sewage; Classification of streams in Georgia; South Carolina and North Carolina; Pollution control by recovery of caustic soda.

VERSATILE ION EXCHANGE RESINS CAN SOLVE POLLUTION PROBLEMS, Am. Textile Reptr., 80, p. 19, 21 and 61, (1966), (Farbenfabriken Bayer AG.).

This paper reports on the treatment of raw textile waters using ion exchange resins. It considers economy of equipment installation in new or remodeled plants.

WATER AND EFFLUENTS, Intern. Dyer 136: 916-917, (Dec. 1966).

Summaries are given of the following papers presented at the half-day symposium by the London Region of the Soc. of Dyers & Colourists on Nov. 4, 1966:

(1) Water for the dyehouse, by T. H. Morton
(2) Water usage in rinsing, by G. J. Parish
(3) Surface-active agents in processes and effluents, by W. V. Barnes and S. Dobson
(4) Treatment of effluents, by A. H. Little

PURIFICATION OF INDUSTRIAL WASTES, Asendorf, Erich.; Chemikerztg., 90, (16), p. 573-578, (1966), (German).

Thumbnail descriptions of processes for the following wastes are given: aldehydes, acetonitrile, acrylonitrile, amines, bisulfite, H_2S, HCN, chromic acid, tanning wastes, fibrous materials, F compounds, carbon dust, dairy wastes, oil and petroleum products, pharmaceuticals, phenols, starch manufg., acids, metal ions, textiles, clay, and sugar.

IN-PLANT PROCESS CONTROL FOR ABATEMENT OF POLLUTION LOAD OF TEXTILE WASTES, Ganapati, S. V.; Environ. Health (India), 8 (3), p. 169-173, (1966).

The redn. of waste production procedures at a textile mill is discussed. It is possible to reduce the vol. and strength of the waste by recovery of certain salvageable substances. It is also possible to recover much waste heat during the processes. A significant quantity of pollution results from the waste of the sizing process. This can be reduced by utilizing chemicals with a lower BOD such as synthetic sizing agents which produce wastes with a much lower BOD than those from natural sizing agents.

THE PURIFICATION OF TEXTILE EFFLUENT, Hamburger, B.; Textil-Praxis, 21, (1), p. 39-41, (1966), (German).

A short survey of physical, chemical and biological methods is made.

ACID PROTECTION AND EFFLUENT TREATMENT IN THE TEXTILE INDUSTRY, W. Heynemann and H. J. Bradke; Spinner Weber Textilveredlung 84, No. 8: 850-857, (1966), (German) Through Shirley Inst. 46: 5243, (1966).

Special treatments to prevent attack by acid on floors of workshops are described; films of polyisobutylene offer short-term protection but bitumen or acid-resistant tiles are needed for permanent protection. A short survey of small-scale effluent treatment tanks is given.

THE STATE OF THE ART OF WATER USE AND WASTE DISPOSAL IN THE TEXTILE INDUSTRY (1950-1966), L. D. Jones and W. L. Hyden; Georgia Inst. of Technol., Water Resources Center, Atlanta, Ga., 30332, (June 1966), 61 p., WRC-0166.

This report provides a comprehensive listing and a general review of the technical literature of textile mill processes related to liquid waste production, treatment, and disposal. It covers the period from 1950 to 1966. Processes related to the manufacture of cotton, wool, silk, flax, and manmade fiber products are discussed. Problems such as excessive color in plant effluents, the effects of synthetic detergents on waste treatment, and waste-heat recovery are high-lighted. Special emphasis is placed on problems which are in need of accelerated research effort.

WATER AND EFFLUENT. PART 4, M. Kehren; Z. ges., Textil-Ind. 68, No. 8: 602-606, (1966), (German) Through Shirley Inst. 46: 4976, (1966).

This supplementary article publishes recent statistics on the consumption of water by industries in Germany, and the most recent news of surface active agents which are biologically degradable. Four recent publications on fatty-acid sugar esters are summarized.

WASTE WATER TREATMENT IN MODERN TEXTILE OPERATIONS, Kuisel, H. F.; Oesterr.-Abwasser-Rundsch., LL, (5), p. 80-84, (1966), (German).

Utilization of Lake Constance as a drinking water reservoir, and an agreement between Austria, Germany, and Switzerland place limitations on waste water into the lake to: suspended solids < 0.3, org. solvents and extractable matter by petroleum ether <10, BOD <25, $KMnO_4$ consumption < 80 mg./l., and absence of toxic matter, and temp. < 30°. Activated sludge is poisoned by chemicals used in the textile industry (phenol, urea-formaldehyde or mineral oils) as these are liberated in biol. treatment. Collection and mixing of all effluents of a textile plant is a partial solution to this problem, having excess Cl decolorizing dyes in soln. The temp. can be controlled by a heat exchanger, which also results in a fuel savings. The water is clarified and treated by activated sludge, to be used as an org. fertilizer. High pH and BOD are reduced by aeration for 48 hours; hard detergents are to be excluded either by legislation or voluntarily. Phenol is to be removed in the plant by ion exchange, and may be recovered. Examples are given of treatment in various textile plants.

ELECTRIC FLOTATION OF SUSPENDED PARTICLES WITH THE USE OF FLOTATION REAGENTS, Matov, B. M.; Elektron. Obrab. Mater., Akad. Nauk. Mold. SSR, (3) p. 80-82, (1966), (Russian).

Waste water from a silk production plant has been clarified by flotation of suspended particles in an electric field. Various flotation reagents were used; Optimum conditions were obtained with 0.4 g/l of ferric chloride.

WATER IN THE SERVICE OF INDUSTRY, Streatfield, E. L.; Chemistry and Industry, Vol 14, p. 569, (1966).

A general survey on textile and other industrial wastes.

QUESTIONS ON WASTE WATERS FROM THE TEXTILE INDUSTRY, F. Taresay, Wass. Boden 18: 276-280, (1966) Through Water Pollution Abstr. 40: 1712, (Oct. 1967).

Textile industry waste waters containing acids, alkalies, dyes, and fibers have a high oxygen demand, and therefore require preliminary treatment. Details are given of laboratory and pilot-plant experiments which have to be carried out by the textile industry in planning the treatment necessary before the waste waters can be discharged to the municipal sewer to reduce the pollution load.

THE BOD OF TEXTILE CHEMICALS: UPDATED LIST - 1966, Am. Dyestuff Reptr., 55, p. 685-688, (1966), RA58 Stream Sanitation Technol., AATCC Committee.

The list gives (1) name of chemical, (2) 5-day BOD %, (3) references, (4) chemical composition and use.

PROCEEDINGS OF THE FOURTEENTH SOUTHERN WATER RESOURCES AND POLLUTION CONTROL CONFERENCE, Dept. of Environmental Sciences & Eng., Univ of N. C., Chapel Hill, N. C. (1965).

> These conferences are sponsored jointly by Duke University, North Carolina State University, and the University of North Carolina. Included in the proceedings is one paper of specific textile interest: Developing patterns for efficient water utilization: textiles, by C. A. Willis, p. 100-104.

TEXTILE EFFLUENT TREATMENT AND DISPOSAL (Papers read at a conference at the Shirley Institute on Nov. 17, 1965). Cotton, Silk & Man-Made Fibres Research Assoc., Shirley Inst., Didsbury, Manchester 20, England, 1966.

> Contents: (1) Planning for trade-effluent disposal, by P. C. G. Isaac, p. 9-34; (2) Treatment of waste waters from the textile industry, by A. B. Wheatland, p. 35-39 (14 refs); (3) Pollution by textile effluents in the Mersey basin, by C. Lumb, p. 60-76; (4) Stratification in sedimentation tanks, by A. H. Little, p. 77-92.

TEXTILE EFFLUENT TREATMENT AND DISPOSAL. THE COTTON AND MAN-MADE FIBRES RESEARCH ASSOCIATION, Shirley Inst. Pamph., 1966, No. 92, 92 pp 20s; At a conference at the Shirley Institute, Manchester, (November 1965).

> The following papers were read: (1) Planning for trade-effluent disposal, Isaac, P. C. G.; (2) Treatment of waste waters from the textile industry, Wheatland, A. B.; (3) Pollution by textile effluents in the Mersey basin, C. Lumb; (4) Stratification in sedimentation tanks, A. H. Little.

A COMPREHENSIVE SURVEY OF INDUSTRIAL WASTE POLLUTION IN SOUTH CAROLINA, Hann, R. W., Jr. and F. D. Callcott: Industrial Waste Conf. (Purdue), 20, p. 538-550, (1965).

> This study discusses the major industries (the textile industry is the largest) using the waters of South Carolina. Their processes are examined and the location and magnitude of their waste discharges noted. The scope of the various industries in relationship to their waste discharges as compared to one another and to the domestic population is calculated. 7 references.

TEXTILE MILL EFFLUENT CONTROL, Lawton, E.; Textile Forum, 23, p. 8-14, 47-57, (1965).

matter, and temp. < 30°. Activated sludge is poisoned by chemicals used in the textile industry (phenol, urea-formaldehyde or mineral oils) as these are liberated in biol. treatment. Collection and mixing of all effluents of a textile plant is a partial solution to this problem, having excess Cl decolorizing dyes in soln. The temp. can be controlled by a heat exchanger, which also results in a fuel savings. The water is clarified and treated by activated sludge, to be used as an org. fertilizer. High pH and BOD are reduced by aeration for 48 hours; hard detergents are to be excluded either by legislation or voluntarily. Phenol is to be removed in the plant by ion exchange, and may be recovered. Examples are given of treatment in various textile plants.

ELECTRIC FLOTATION OF SUSPENDED PARTICLES WITH THE USE OF FLOTATION REAGENTS, Matov, B. M.; Elektron. Obrab. Mater., Akad. Nauk. Mold. SSR, (3) p. 80-82, (1966), (Russian).

Waste water from a silk production plant has been clarified by flotation of suspended particles in an electric field. Various flotation reagents were used; Optimum conditions were obtained with 0.4 g/l of ferric chloride.

WATER IN THE SERVICE OF INDUSTRY, Streatfield, E. L.; Chemistry and Industry, Vol 14, p. 569, (1966).

A general survey on textile and other industrial wastes.

QUESTIONS ON WASTE WATERS FROM THE TEXTILE INDUSTRY, F. Taresay, Wass. Boden 18: 276-280, (1966) Through Water Pollution Abstr. 40: 1712, (Oct. 1967).

Textile industry waste waters containing acids, alkalies, dyes, and fibers have a high oxygen demand, and therefore require preliminary treatment. Details are given of laboratory and pilot-plant experiments which have to be carried out by the textile industry in planning the treatment necessary before the waste waters can be discharged to the municipal sewer to reduce the pollution load.

THE BOD OF TEXTILE CHEMICALS: UPDATED LIST - 1966, Am. Dyestuff Reptr., 55, p. 685-688, (1966), RA58 Stream Sanitation Technol., AATCC Committee.

The list gives (1) name of chemical, (2) 5-day BOD %, (3) references, (4) chemical composition and use.

The varied character of textile wastes, waste recovery systems, analysis of waste waters, and methods of waste treatment are described.

THE EFFECT OF INDUSTRIAL EFFLUENTS ON SOIL FILTRATION, H. Reploh and H. Kustermann; Arch. Hyg. Bakteriol. 149, No. 7/8: 627-635, (1965), (German) Through J. Textile Inst. Abstr. 57: W624, 1966.

Soil filtration of sewage was found to be effected, detrimentally, by textile-mill effluent. Tests showed that the highly alkaline effluent reduced the filtering speed of the soil by dissolving humus substances, but that this could be overcome by neutralizing the effluent with sulfuric acid.

WASTE DISPOSAL BY TEXTILE PLANTS, A. L. Smith (Chatham Mfg. Co.), J. Water Pollution Control Fed. 37: 1607-1613, (Nov. 1965).

Sources of wastes and general methods of removal are discussed, followed by two examples: (1) how a multifiber woolen mill solved a problem in solids removal and in incomplete treatment, and (2) how a plant processing synthetic fibers made good use of aeration for handling sludge.

TREATMENT STUDIES OF COMBINED TEXTILE AND DOMESTIC WASTES, Lauria, D. T. and C. A. Willis; Proc. 19th Ind. Waste Conf., Purdue Univ., Engng. Extn. Ser. 117, p. 45-58, (1964).

At Valdese, N. C., more than 80 percent of the total waste flow consists of waste waters from the dyeing and finishing operations at textile mills. The existing sewage works are overloaded and, since the effluents are discharged to a creek flowing into a lake used for recreational and water-supply purposes, it was decided to carry out pilot-plant experiments to obtain data for the design of a new plant for biological treatment of combined domestic sewage and textile waste waters. The method of treatment chosen was a low-loading completely-mixed process, and results showed that reductions in BOD of 90 percent could be obtained with BOD loadings of at least 2 lb. of BOD per lb. of sludge per day. The proposed new plant, which will have a capacity of 3.2 m.g.d., will comprise facilities for screening and grit removal, lagoons with mechanical surface aerators, sedimentation tanks, facilities for chlorination of effluents, and a solid-bowl centrifuge for thickening excess sludge before disposal as landfill.

APPLICATION OF THE DISSOLVED OXYGEN ELECTRODE TO THE TREATMENT OF INDUSTRIAL WASTES, Mathews, L. A.; Proc. S. Munic. Ind. Waste Conf., 13, p. 89-96, (1964).

Determination of oxygen up-take and respiration by aerated sludges of textile and dyeing wastes treated by the activated sludge process is discussed.

HYGIENIC ASPECTS OF THE TREATMENT OF TEXTILE INDUSTRY WASTE WATERS CONTAINING CHROMIUM SALTS, USED FOR IRRIGATION, Sedova, G. P.; J. Hyg. Epidem. Microbiol. Immun., 8, p. 281, (1964); and Zentbl. Bakt. Parasitkde, I, 200, Ref., p. 407, 1965.

Details are given of experiments carried out on the treatment of textile industry waste waters containing chromium salts for use in irrigation. Results showed that trivalent and hexavalent chromium, present in clay soil in amounts of 0.1 mg. per 100 g. of soil, had no adverse effects on the nitrification process. Irrigation with undiluted waste waters containing chromium inhibited the formation of nitrate-nitrogen in the soil but had a growth-promoting effect on plants such as cabbage, carrots, and tomatoes. When using waste waters containing chromium for irrigation, the waste water must be diluted, so that the chromium content does not exceed 0.5 mg. per litre and the amount of irrigation should not exceed 2000 m^3 per ha.

THE ECONOMICS OF BASE METAL RECOVERY BY ION EXCHANGE, A. B. Mindler (Permutit Co., Paramus, N. J.), Met. Soc. Conf. 24, 851-8, discussion 858-0, (1963).

Data are presented to demonstrate that industry producing base metals may profit by ion exchange, esp. where the metal concn. is low. The examples are taken from the textile industry in which 5000 tons Cu and Zn, as oxides, are recovered each year from waste solns. Costs are given for the Zn circuit, but the costs should be similar for a Cu circuit. Also a new process (abiperm) is described for recovering Na from sulfite pulp waste liquors.

COTTON WASTE TREATMENT

PROCESS FOR SIZING TEXTILES AND THE DISPOSITION OF SIZING WASTES THEREFROM, Bode, H. E.; U.S.P. 3,093,504.

By allowing starch to react with alkali metal phosphates under prescribed conditions, involving heating in a semi-dry state, it is claimed that reagents can be produced which develop colloidal properties suitable for sizing cotton warp at a relatively higher viscosity than that required with the parent starches. As a result, only about half the usual weight of size is required and only half the usual weight of size solids appear in the desizing liquor, thus reducing the pollution load. In addition, desizing can be carried out simply by heating in water, with no resultant degradation of the basic starch molecule, and the desizing liquor can be used as make-up liquor for further desizing; alternatively, it can be treated to recover the starch solids by precipitation with a material, such as barium hydroxide or lime, which will supply a cation to neutralize the charge on the anionic starch polymer; after removal of the precipitated starch phosphate by centrifuging, filtration, or sedimentation, the effluent is substantially free from B.O.D. attributable to the starch size.

WASTE TREATMENT STUDIES AT CLUETT, PEABODY AND COMPANY FINISHING PLANT, R. H. Southern; Am. Dyestuff Reptr. 58: 13-16, (July 1969).

Data on pollution effects of textile processing wastes, effects on modified extended contact bio-aeration, and effects of in-plant mercerizing caustic recovery are given. The results of trials with caustic soda recovery units are discussed.

KINETICS OF REMOVAL OF STARCH IN ACTIVATED SLUDGE SYSTEMS, Banerji, S. K., B. B. Ewing, R. S. Englebrecht, and R. E. Speece; J. Water Pollution Control Fed., 40, (2), Part 1, p. 161-173, (1968).

A laboratory-scale study of the kinetics of starch removal in activated sludge systems revealed that first-order kinetics prevail during the initial aeration period, with the removal-rate constant dependent on food-to-microorganism ratio rather than on initial sludge concentration. Removal of total chemical oxygen demand follows zero-order kinetics and depends on initial mixed liquor suspended solids. The effect of temperature on both removal rates is significant. In aerobic systems, further breakdown of starch breakdown products occurs inside microbial cells. Anaerobiosis has no effect on starch degradation under good mixing conditions, but greatly retards total COD and total carbohydrate removals.

MECHANISM OF STARCH REMOVAL IN THE ACTIVATED SLUDGE PROCESS, Banerji, S. K., B. B. Ewing, R. S. Englebrecht, and R. E. Speece; J. Water Pollution Control Fed., 40, p. 16-29, (1968).

A laboratory experiment on the removal of starch from textile desizing processes is reported. An explanation of the mechanisms involved in removal of potato starch by activated sludge is offered.

EFFECT OF THE QUANTITY OF WATER USED IN FABRIC BLEACHING ON THE DEGREE OF WHITENESS ATTAINED AND ON THE CONTENT OF IMPURITIES IN EFFLUENT, H. Jakubowica; Tech. Wlok. 17, No. 10: 316-318, (1968), (Polish) Through Shirley Inst. 48: 5705, (1968).

Experimental work on the bleaching of cotton fabrics and viscose in rope form on Kleinewefers, Benteler, and QL-1 equipment is reported.

COMBINED TREATMENT OF COTTON MILL AND DAIRY WASTES WITH SEWAGE, Petru A.; Water Waste Treat., 11, (12), p. 532-533, (1968).

The combined treatment of cotton mill and dairy wastes with sewage was evaluated by treating synthetic sewage made from dried milk and textile wastes from an operating cotton mill. The wastes were tested manometrically. These manometric tests were followed by tests in a laboratory model, two-stage activated sludge plant. The combined waste could be effectively treated. Shock loading of alkaline pH was adequately handled. S^{2-} 17, Cr 1.68 (as $K_2Cr_2O_4$), and Cu (as $CuSO_4$) 41 mg./l. were without effect. Retention times of one hour in the primary and three hours in the secondary stage yielded acceptable results.

USES OF CAUSTIC SODA RECOVERED FROM THE MERCERIZATION PROCESS IN THE TEXTILE INDUSTRY, D. F. Becknell; Master's Thesis, Georgia Inst. of Technol., Atlanta, Ga. (1967).

Recovery and reuse of sodium hydroxide from the mercerization of cotton textiles have been investigated for the purposes of economy and reduction of water pollution.

THE TREATMENT OF KIER LIQUOR IN A MIXTURE WITH SEWAGE, K. A. Deighton; Water Pollution Control 66, No. 5: 484-491, (1967) Through Shirley Inst. 48: 177, 1968.

> It has been established that Greenfield (Lancastershire) sewage containing kier liquor and other trade effluents can be successfully purified by two-stage treatment using a partial-treatment activated-sludge plant followed by biological filtration. While no set of conditions ensured a 30:20 effluent at all times, departures from this were generally slight. On average, during the later stage of the experiment, effluents were within the 30:20 standard.

RECIRCULATION AT SEWAGE WORKS TO DEAL WITH KIER COTTON LIQUOR, Munic. Engng., Lond. 144: 2317, (1967) Through Water Pollution Abstr. 41: 1633, Sept. 1968.

> An illustrated description is given of new sewage works under construction that are designed to treat a dry-weather flow of 0.75 m.g.d., including 0.1 m.g.d. of cotton kiering wastewaters. Treatment is by biological filtration with 1.1 recirculation of effluent and results are given of pilot-plant experiments showing reductions in biological and chemical oxygen demand obtained with single and alternating double filtration. With alternating double filtration and 1.1 recirculation, a biological oxygen demand reduction of 95.7% was achieved.

SODIUM HYDROXIDE RECOVERY IN THE TEXTILE INDUSTRY, C. S. Carrique and L. U. Jauregul; U. Proc. 21st Ind. Waste Conf., Purdue Univ., Engng. Extn. Ser. No. 121: 861-868, (1966) Through Water Pollution Abstr. 40: 1891, Nov. 1967.

> The Castelar textile mill in Buenos Aires, Argentina, has provided a treatment plant for coagulation of the waste waters with aluminum sulfate, followed by chlorination before discharge to a storm drain. Since the waste water from the cotton mercerizing process is very alkaline, it was decided to segregate it for recovery of sodium hydroxide; the waste water is filtered to remove fine colloidal matter and is then evaporated in a double-effect system to produce colorless concentrated sodium hydroxide. Diagrams of the recovery system are included and the costs are estimated.

IN-PLANT PROCESS CONTROL FOR ABATEMENT OF POLLUTION LOAD OF TEXTILE WASTES, S. V. Ganapati; Environ. Health 8, No. 3: 169-173, (1966) Through Chem. Abstr. 66, No. 6: 21985, 1967.

> Reduction in the volume and strength of textile mill waste by recovery of certain salvageable substances (and also recovery of waste heat) is discussed. A particular aspect mentioned is the reduction of sizing waste; this can be effected by using synthetic sizing agents which produce wastes with a much lower BOD than those from natural sizing agents.

WASTE LIQUORS FROM THE MERCERIZATION OF COTTON FABRICS AND LIMITING OF WASTE WATER ALKALINITY, Jaromir Nosek; Vodni Hospodarstvi 16 (7), 288-91, (1966), (Czech).

> In the mercerization process, the consumption of mercerization caustic depends mainly on the humidity of the fabric entering and leaving the mercerization machine. To reduce the caustic consumption, increased wringing by the machine and use of waste liquor for the dissoln. of the fresh caustic are suggested.

TREATMENT OF WASTES FROM COTTON TEXTILE INDUSTRY, Rao, V. Rama; Technology (Sindir), Spec. Issur. 3, (4), p. 56-58, (1966).

> The vol. of waste water discharged from 87 cotton textile mills at Ahmedabad (India) varies between 10,000 and 3,000,000 gal./day. Waste waters are chiefly from bleach and dyehouse and contain fibrous and suspended solids. Owing to great variations in the characteristics of the waste water, it was not appropriate to mix it directly with sewage. Modified pretreatment methods of waste treatment in each plant were worked out, which consists of coagulation by lime and gypsum followed sedimentation and filtration through a gypsum filter.

BIOLOGICAL PURIFICATION OF PRODUCTION EFFLUENTS FROM COTTON BLEACHING, Zawadzki, Jerzy; Biul. Inst. Wlok., 17, (2), p. 1-5, (1965), (Polish).

> Investigations were made on a lab. scale on the possibility of purifying waste waters from cotton bleaching for further utilization. Purifications were carried out by the activated sludge method. To ensure the development of microorganisms, 1 g. K, P, and N (in form of NH_3)/m.^{3} of effluents. It was impossible to det. on the lab. scale the optimum amt. of air needed for decreasing 5-day

BOD in effluents. The purified waste waters could be reused for rinsing raw cotton after bleaching.

UNIQUE TREATMENT SYSTEM FOR CHEMICAL COTTON WASTES, B. W. Dickerson (Hercules Powder Co., Wilmington, Del.), Proc. Ind. Water Waste Conf. 5th, Dallas, (1965), 397-427.

Processing of cotton linters consists essentially of cooking with a caustic liquor, washing, bleaching, packaging, and passing the purified product through a regular paper machine. Three methods of handling the wastes were investigated: evapn., burning, and recausticization for recovery of caustic soda; the Zimmerman process; and biol. oxidn. The last method appeared to be the most feasible. Batch aeration studies showed that with proper diln., pH adjustment, and nutrient addn., the composite waste was amenable to such treatment under aerobic conditions. Semipilot-plant studies showed that good purification of the waste may be obtained with an aeration period of 16-24 hours. Based upon the data obtained in these studies, a pilot-plant operation was devised. After months of operation, sufficient data was accumulated for design criteria to be developed. The full scale plant design developed is described and also shown pictorially.

WOOL WASTE TREATMENT

THE CENTRIFUGAL RECOVERY OF WOOL GREASE, Wool Sci. Rev. No. 37: 23-36, (Oct. 1969).

> Various aspects of the centrifugal method are discussed in this paper and a procedure is given for achieving maximum profitability. The topics covered are: structure of the wool scour liquor, general principles of recovery, primary separation, the secondary centrifuge, the purifier centrifuge, and scouring and centrifuging procedures for maximum grease recovery. The economics of wool grease recovery and the future demand for wool grease are also covered.

NEW ZEALAND WOOL SCOURING LIQUORS-TREATMENT AND POTASSIUM RECOVERY, J. L. Hoare, R. G. Stewart, and B. J. Sweetman; N. Z. J. Sci. 12, No. 2: 237-251, (1969) Through World Textile Abstr. 1: 5694, (1969).

> Some results are given of the effect of acidification on a series of nonionic detergent stabilized New Zealand wool scouring liquors. By treatment with sulfuric acid to pH 3.5 the emulsion is cracked but phase separation is generally poor. The potassium contents of 67 samples of 48s Romney Crossbred wool were determined and two methods of recovering potassium from wool washings were examined on a laboratory scale. At present the most satisfactory way of treating effluent from wool scouring is in admixture with domestic wastes in a conventional treatment plant.

WATER POLLUTION: SPECIFIC POLLUTION BY GREASY WOOLS, B. Koussens; Bulletin Trimestriel. Centre Textile de Controle et de Recherche Scientifique No. 74: 236-245, 1968, (French) Through World Textile Abstr. 1: 848, (1969).

> The effluents from the scouring of several types of greasy merino and crossbred fleece wools and Mazamet skinwool were analyzed for matter in suspension, biological oxygen demand, chemical oxygen demand, and organic matter content, the last three being determined after being decanted for 2 hrs. Soap-soda and detergent scours were compared.

PURIFICATION OF EFFLUENT FROM WOOL SCOURING MILLS, Y. Y. Lur'e and P. S. Antipova: Tekstil, Prom. 28, No. 2: 13-14, (1968), (Russian) Through Shirley Inst. 48: 2244, (1968).

> A chemical method for the removal of anionic synthetic detergents

from wool scouring wastes which contain too high a concentration for discharge into a municipal sewage works is described. It involves the use of potassium aluminate or other sorbents which act in alkaline medium; in the experimental work this was used to remove dodecylbenzenesulfonate from the effluent.

CHEMICAL AND BIOLOGICAL TREATMENT OF WOOL-SCOURING WASTE, Ogawa, Hiroshi; Horikawa, Kunihiko; Yasuda, Makoto; Kagami, Tsunejiro (Kanagawa-ken Kogyo Hokoku), (1968), (21), 35-45, (Japanese).

Coagulation and subsequent activated sludge treatment for wool scouring waste was investigated. Gravitational sedimentation was effective for inorg. substances but not for oily org. substances. Acid sedimentation by H_2SO_4 reduced S.S. < 6000 in 70-80% efficiently at pH 3-4. After the acid sedimentation, B.O.D. and C.O.D. were reduced to 400-5600 and 146-1630 ppm., followed by neutralization with $Ca(OH)_2$. Grease recovery was investigated regarding solvent ($ClCH_2CH_2Cl$, CCl_4, CS_2, n-hexane, and petroleum ether) extn. and centrifugal method. After the chem. treatment B.O.D. and C.O.D. were reduced to 900-1500 and 400-800 ppm. resp. In final activated sludge treatment C.O.D. 75% and > 1-2 hrs. B.O.D. 75% elimination was achieved. After over-all treatment B.O.D. and C.O.D. were reduced to 15-70 and 60-120 ppm., resp., and the transparency >30 cm.

BIOLOGICAL TREATMENT OF WASTE WATER FROM WOOL WASHING PLANTS WITHOUT CHEMICAL PRE-TREATMENT, A. Petru. Vod. Hospod. 17: 108-109, 1967, (Czech), (English summary) Through Water Pollution Abstr. 41:878 (May 1968).

Previous experiments have shown that wool washing waste waters could be treated biologically in admixture with sewage after preliminary chemical treatment, and further experiments have now been carried out to investigate the possibility of omitting the chemical treatment. The results showed, however, that satisfactory treatment could be achieved only by a two-stage biological process, treating a mixture of 1 part of waste water to 80 parts of sewage.

ACID METHOD FOR ADDITIONAL DEGREASING OF WASTE WATERS OF WOOL-WASHING PLANTS, Radvinskii, M. V.; Martynova, A. P. (USSR). Vodosnabzh, Kanaliz. Gidrotekh. Sooruzh. Mezhved. Resppub. Nauch.-Tekh. Sb. 1967, No. 5, 87-7 (Russian) From Ref. Zh., Khim. (1968), Abstr. No. 121497.

Waste waters contain significant amt. of wool fat after flotation and sepn. About 60-70% of the indicated H_2SO_4 content is spent for alky. neutralization of waste waters and only 30-40% for acidification to pH 3.5. Before releasing the degreased waste waters into the effluent system, they can be neutralized by partial combination with alk. rinsing waters of the last vats. Acid demulsification of predild. waste waters at 40-50° resulted in favorable wool fat pptn. process.

EFFLUENTS AND BYPRODUCTS, R. E. F. Gardner, F. Hunter and P. Ramsden (City of Bradford Sewage Dept.); J. Bradford Textile Soc: 89-95, (1967-1968).

The three authors give separate accounts of the water supply, water pollution, and sewage purification in Bradford in relation to the high concentration of the wool scouring industry there.

EXPERIENCES WITH PLANTS TREATING WASTE WATERS FROM THE WOOL INDUSTRY, Lebedev, M., and Agalova, V.; Vodosnab. sanit. Tekh., (1967), No. 4, 34-37.

Details are given of experiences in the treatment of wool industry waste waters at a mechanical-biological plant in Ulan-Ude, U.S.S.R. The plant, which has been operated successfully for two years, provides two-stage biochemical treatment, and the sludge is used as manure.

FINANCIAL RETURN FROM INDUSTRIAL WASTE PRE-TREATMENT, Reich, J. S.; Proc. 22nd Industrial Waste Conference, Purdue Univ., Extension Service, Vol. 129, p. 92, (1967).

Article discusses problems encountered with wool waste in the city of Philadelphia. Several wool fulling and scouring plant discharges to the city's biological treatment plans have caused problems. It was found that fibers were being lost that could be recovered at a profit. The plants made changes in their waste screening procedures and recovered this valuable material.

INVESTIGATIONS INTO THE CENTRIFUGING OF WOOL-SCOURING LIQUORS FOR WOOL-GREASE RECOVERY. I. THE PRIMARY CENTRIFUGE, Anderson, C. A., and G. F. Wood; J. Text. Inst., 57, p. T55-T64, (1966).

Experiments were carried out using an Alfa-Laval sludge-discharge centrifuge, type FVK4, to determine the effect of various factors on grease recovery. In general the centrifuge was inefficient at settings that gave very low or very high conc. of grease in the product, the optimal conc. being 15+/-5%; procedure is described for adjusting the centrifuge for optimal production.

EQUIPMENT FOR WASHING AND DEGREASING WOOL, Spinner Weber Textilveredlung 84, No. 5: 533-534, (1966), (German) Through Shirley Inst. 46: 3359, (1966).

A method due to the Stiftelsen Svensk Textilforskning gives wool a rhythmical shaking in the liquor which should not cause felting. Two others methods are described in which the wool is sprayed with aqueous detergent solution. A variation of the CSIRO method is for the treatment of lumpy wool without causing further felting.

WATER POLLUTION, Lab. Essais Chambre Comm. Magamet No. 2: 16-22, (1965), (French) Through J. Textile Inst. Abstr. 57: W625, (1966).

Results are reported from a simple installation of two decanting tanks for treating effluent in a Magamet de-wooling plant where water is supplied from a stream that is also the outlet for effluent.

CARPET MANUFACTURING EFFLUENTS AND THEIR TREATMENT, Evers, D.: J. Proc. Inst. Sew. Purif., Part 5, p. 464-470, (1966).

Carpet processing effluent is divided into categories - effluent from (1) scouring of raw wool and yarn, (2) dyeing, (3) sizing, (4) latexing, (5) moth-and mildew-proofing. If a firm discharges all these effluents, the smaller volumes of effluent from latexing and proofing will be lost in the larger volumes from scouring and dyeing. If only dyeing and latexing are carried out, acid dye liquors will precipitate latex and clog sewers.

FIT WASTE WATER TREATMENT TO INDUSTRIAL PROCESS, Nebolsine, R. and Donovan, E. J.; Plant Engineering, Vol. 20, p. 140, (1966).

Discusses the treatment of wool along with other wastes.

PRESENT STATUS OF INDUSTRIAL WASTE-WATER TREATMENT INSTALLATIONS, Pais, G.; R. Mitroiu, and H. Weinberg; Hidroteh. Gospodarirea Apelor Meteorol., II, (3), p. 149-155, (1966), (Rumanian).

Figures for silk and wool industries are included in analytical data (pH values, total suspensions, and organic matter) on waste waters from various industries. Methods of waste water treatment are also discussed.

PHYSICAL/CHEMICAL CHARACTERISTICS OF WOOLEN MILL EFFLUENT AND PURIFICATION TRIALS, M. Rusanovschi, E. Iliescu, and B. Zilberstein; Industria Textila 17, No. 3: 160-164, (1966), (Rumanian) Through Shirley Inst. 46: 3503, (1966).

> Qualitative and quantitative analyses of the waste waters from woolen mills have been investigated and an attempt has been made to establish a purification technique which will treat the effluent to such an extent that final purification may be carried out at the domestic sewage plant. Two purification techniques are suggested: chemical coagulation and absorption.

BIOLOGICAL TREATMENT OF WOOL SPINNING WASTES, Tanaka, M., Dazai, M., and Ono, H.; Hakko Kogaku Zasshi (Japan), 42, 5, 306, (1964): Chem. Abs., 64, 19181, (1966).

> Article covers work on the mophilic methane fermentation of wool spinning waste. The digested liquor was mixed with the dye liquor and backwash water and treated in an activated sludge plant.

METHOD FOR DISPOSAL OF INDUSTRIAL WASTE WATER, Yoshikara, A., Yoshikara, T., Okada, K. and Sakaguchi, S.; U. S. Patent 3, 163,598; Jour. Textile Inst. Abs., 57, 626, (1966).

> Authors covered the treatment of wool wastes with wood, charcoal or the like, then treatment with zinc compounds (cheap by-products of industrial processes).

DEVELOPMENT TRIALS OF PLANT FOR THE CONTINUOUS PURIFICATION OF SOLVENT-EXTRACTED WOOL GREASE, J. Brach; Ann. Sci. Textiles Belges No. 4: 65-85, (1965), (French) Through J. Textile Inst. Abstr. 57: W243, (1966).

> Plant for the continuous treatment of solvent-extracted wool grease by the De Smet Neumi process is described. The extracted grease is mixed with hexane, alcohol, water, and soda. After decanting into three phases, treatment with alcohol and water removes any traces of soaps from the upper phase, the solvent is distilled from the grease, and the hexane and alcohol are collected. Alcohol is recovered by water from the hexane, which is then available for reuse. Data of the properties of the purified grease and of the operation of the plant are reported.

TREATMENT OF WOOL SCOURING LIQUORS, E. W. Clark and G. F. Kitchen (to Woolcombers Ltd. and Westbrook Lanolin Co.), BP 1 029 114, (May 1965), Appl. Apr. 21, 1964.

> The invention covers a method for removing detergents from the waste liquor to facilitate recovery of wool grease and produce a purer effluent for disposal in public sewage systems.

EFFLUENT CONTROL IN THE CARPET INDUSTRY, Evers, D.; Textile Inst. Ind. 3, p. 237-240, (1965).

> The characteristics of effluents resulting from scouring, dyeing, sizing, latexing, mothproofing, and mildewproofing are discussed.

DISPOSAL OF WOOL SCOURING RINSINGS, Y. Yajima, N. Todo, T. Oda, and G. Fujiwara (to Kanematsu Woolen Mills Ltd. and Takuma Boiler Mfg. Co. Ltd.), BP 1 128 921, Oct. 2, 1968, Appl. (Japan) (Oct. 1964).

> The scouring effluent is separated into coagulated matter or sludge and waste water suitable for discharge into public drainage and the sludge is treated further to recover wool fat and fertilizer by means of solvent treatment.

THE PURIFICATION OF WASTE WATER FROM WASHING WOOL BY MEANS OF ANAEROBIC FERMENTATION, E. E. Grishina; Vodosnabzh. i Sanit. Tekhn., (1964), (12), 24-7, (Russian).

> The construction and working of a pilot plant for purifying the waste water from washing wool by filtration and anaerobic fermentation is described. The method makes possible a decrease of the pH to 8.3, the abs. B.O.D. to 25-30 mg./1/ and a complete elimination of the wool fat. The NO_3^- and NO_2^- content of the purified waste water was 31 and 0.1 mg./l., resp.

RECOVERY OF FIBROUS MATERIAL FROM WASTE WATERS OF THE PAPER, CARDBOARD AND CELLULOSE INDUSTRY, H. Sommer, H. Bestian, and D. Bergmann (to Farbwerke Hoechst AG), USP 3 399 110, Aug. 27, 1968, Appl. (Germany), (Mar. 1964).

> The process consists of adding to the waste water a nitrogenous product obtained by the condensation of urea and a 1, 2-alkylene-imine or oligomer.

MAN-MADE FIBER WASTE TREATMENT

PILOT WASTE WATER STUDY GIVES ENCOURAGING INDICATIONS, R. S. Sahlie and C. E. Steinmetz (Fiber Inds., Inc.). Modern Textiles Mag. 50: 26-28 (Nov. 1969).

> Early results are reported from operation of a pilot plant designed to discover the most efficient methods for treating effluent from polyester fiber manufacture for reuse.

THERMAL DECONTAMINATION OF WASTE WATER FROM THE PRODUCTION OF ANID (nylon 66) FIBERS, Bernadiner, M. N. Shurygin, A. P.; Esilevish, G. S.; Lepakhin, I. A.; Baskova, N. K.; Kazanskii, A. A. (USSR). Khim Volokna (1960), (4), 67-70 (Russian).

> The concn. of $H_2N(CH_2)_6NH_2$(I) in the waste effluents of a nylon 66 plant near Kiev is $\leq$0.2 wt. %. The amt. allowed by Soviet law of this toxic compound is $\leq$0.01 mg./l. in water and 0.001 mg./l. in the air. Hot effluents are sprayed into the top section of a cyclone furnace directly into the flame jets of burning natural gas-air mixts. The combustion of I is nearly 100%.

PURIFICATION OF SEWAGE FROM CELLULOSE FIBER PRODUCTION, Kaeding, Joachim; Erdtel, Lothar; Oehme, Rudolf. (German) (East) 62, 267 (Cl. C 02c), (05 Jun. 1968), Appl. 10 Jul. 1967.

> The title process is carried out by mixing alk., cellulose-production sewage with some of the acid sewage, followed by flocculation, sedimentation, aeration, and biol. purification steps. Thus, heavily loaded alk. sewage and part of the less heavily loaded acid sewage are put in settling tanks for 2 hrs. and then measured together into a 3rd tank in a suitable ratio to give pH 2.5-3.0, whereupon α and β -cellulose are pptd. with some adsorbed Zn compds. The acid liquor from the latter settling vessel is mixed with excess acid sewage from the beginning of the process and neutralized with chalk or NaOh to pH 8-9, whereupon Zn salts are pptd. Nutrients are added, e.g. N and P salts, and the sewage is put into another settling tank for 1 hr. and then into an activated-sludge, biodegradation vessel for 4 hrs. where the residual γ -cellulose is degraded.

SCHEME FOR THE REMOVAL OF ZINC IONS FROM EFFLUENT BY CATION EXCHANGERS IN A FLUIDIZED BED, Khim-Volok. (USSR), 6, p. 65, 1967; Shirley Inst., 48, 450 (1968).

> Discusses an ion exchange method of zinc recovery from viscose fiber production using a sodium type cation exchanger. The viscose production waste waters were not screened or settled but put directly through the two ion exchange columns. After this treatment, the zinc was reduced to 0.01 mg./l.

BIOCHEMICAL CLARIFICATION OF WASTE WATERS CONTAINING CAPROLACTUM, Kulakov, E. A., et. al.; Tr. Vses., Nauch-Issled. Inst. Vodosnabzhenii, Inst. Gidrogeol. (USSR), 14, 18 (1966); Chem. Abs., 68, 15914, (1968).

> A discussion of biological purification of caprolactum containing waters. It can be treated in two ways: (a) using 5 mg/l of phosphorus providing the BOD is less than 500 mg/l., and (b) the addition of municipal waste water. The same biological process can be used for either.

EFFLUENT TREATMENT IN THE MANUFACTURE AND PROCESSING OF MAN-MADE FIBERS, F. Rub.; Chemiefasern 18, No. 7: 524-526 (1968). (German) Through Shirley Inst. 48: 3776, (1968).

> The author describes a clarification plant (a Lubecker tank), a biological treatment system, and the Cyclator and its use in flocculation.

VISCOSE WASTE-PROFILE OF A SUCCESSFUL POLLUTION CONTROL PROGRAMME, Woodruff, P. H.; Moore, W. J.; Sitman, W. D.; and Omohundro, G. A.; Wat. Sewage Wks. (1968), 115, 441-450.

> An illustrated description is given of the plant constructed to treat cellophane manufacture waste waters. On the basis of extensive laboratory and pilot-plant studies, results of which are tabulated, the contact-stabilization process was selected; preliminary neutralization of the waste waters and addition of nutrients are necessary. The limited data available on the performance of the plant indicate that reductions in BOD and COD of 80 and 75-85 percent, respectively, can be achieved.

RECOVERY OF ZINC FROM VISCOSE RAYON WASTE, Chakrabarty, R. N.; Saxene, K. L.; Chattopadhya, S. N. (CPHERI Field Centre, Kanpur, India). Environ. Health India, (1967), 9 (4), 296-305.

> Chem. pptn. was much superior to ion exchange for the removal of Zn. A typical flow diagram contains 2 flocculators; the pH is increased to 6 in the 1st one with CaO and to 9 in the 2nd with NaOH. The sludge from the 1st flocculation is discarded, while that from the 2nd is treated with H_2SO_4 and the recovered Zn is reused in the rayon process.

RECOVERY OF ZINC FROM SPINNING BATH WASTE OF A VISCOSE RAYON FACTORY BY ION-EXCHANGE PROCESS, Bhakuni, T. S.; and Bopardikar, M. V., Envir. Hlth, India, (1967), 9, 327-338.

> An ion-exchange laboratory process for the recovery of zinc from spinning bath solution in a viscose rayon factory is described, in which the zinc is adsorbed on a polystyrene-based sulphonic cation-exchange resin in hydrogen or sodium form and eluted with dilute sulphuric acid. Percentage recoveries of over 90 percent were obtained.

INDUSTRIAL EFFLUENT REUSE, Day, W. J.; Southern Engineer, Vol. 85, 56, (1967).

> Author discusses the reuse of water from Fortrel polyester fiber production. The author describes a new plant to be built where water reuse will be necessary and economically feasible. Pilot work was carried out at the extended-aeration activated sludge disposal facilities of a similar type plant. Plans call for the use of a plastic media trickling filter preceding the activated sludge portion to reduce the cost of the mechanical aerators. This was followed by: polishing ponds, algae removal screens, and activated carbon (to remove organic matter). The recovered water was to be used mainly as cooling water make-up. This will require a continuous blow-down to control inorganic solids.

THE PURIFICATION OF WASTE WATER IN THE PRODUCTION OF POLYAMIDE-FIBER, Kaeding, J.; Fortschr. Wasserchem. Ihrer Grenzgeb., 5, p. 258-283, (1967), (German).

> Water from the production of polyamide fibers by the steeping and direct spinning processes was contaminated with org. substances, such as ε -aminocaprolactam oligomers, products, and

detergents. Further knowledge concerning the amt. (55-7 m.^{3}/ton) and kinds of impurities and how they can be treated was sought. Lab scale tests were carried out on a 2-stage biol. treatment followed by flocculation. Holding times of 6-8 hours sufficed for the decompn., which was effected with more certainty and greater capacity at 30° than at 20°. The lactam N was consumed by the microorganisms, so that only phosphates had to be added for microbial decompn. Substances not easily biodegradable were removed from the waste water by adsorption with coagulants ($Al_2(SO_4)_3 \cdot 18H_2O$; $FeCl_3 \cdot 6H_2O$; $FeSO_4 \cdot 7H_2O$; CaO) and the decompn. capacity was then approx. that of lactam-contg. water.

PURIFICATION OF WASTE WATERS FROM THE VISCOSE RAYON INDUSTRY, Kulakov, E. A.; and I. N. Myasnikov; Zh. Vses. Khim. Obshchest., 12, (6), p. 638-644, (1967).

The purification of waste waters obtained from production of viscose silk (900 m.^{3}/ton), viscose reinforced staple (500 m.^{3}/ton), viscose cord (700 m.^{3}/ton), and cellophane (750 m. 3/ton) is described. Sep. processes are suggested for removing all impurities, including acidity 4-8.5 meq./1., pH 2.5-2.8, CS_2 20-100, H_2S 5-25, Zn 20-75, suspended material 120-470, dry residue 2700-6500, and calcined residue 2200-3500 mg./1.

FUNCTION OF SEDIMENTATION TANKS IN SEMI-INDUSTRIAL PLANT FOR EFFLUENT PURIFICATION, Malikov, V. A.; Khim. Volok.; (3), p. 64-66, (1967), (Russian).

Experimental work on the use of vertical and horizontal settling tanks in the purification of viscose-production effluent is reported. The vertical tanks are shown to have three times the capacity of the horizontal tanks in achieving the same degree of purification but the problem of removal of the sediment is more complex.

EXTRACTION OF ZINC FROM INDUSTRIAL WASTE WATERS, Shrylev, L. D. and Mokruslun, S. G.; Zuhr. Priklad. Khim. (USSR) 40, 72 (1967); Chem. Abs., 66, 79391, (1967).

Removal of zinc by successive treatment with solutions of Na_2SO_4, $FeSO_4$, and NaOH is discussed. The final separation of zinc was carried out by flotation.

ACTIVATED SLUDGE TREATMENT OF SOME ORGANIC WASTES, Wheatland, A. B.; Proc. 22nd Ind. Waste Conf., Purdue Univ. Extention Service, Vol. 129, p. 983, (1967).

Discusses laboratory work on the activated sludge treatment of synthetic fibers waste. The work was carried out in three stages: (a) Neutralization and precipitation followed by activated sludge treatment, (b) activated sludge treatment alone without pretreatment, and (c) mixing the cooling waters, the waste material, and domestic waste-water for treatment with activated sludge. Carried out on nylon, terylene and polyacrylic-dyeing wastes.

SEWAGE TREATMENT IN VISCOSE FIBRE PRODUCTION, Economic Commission for Europe. Water Poll/Econ/Working Paper 25, (1966).

At a meeting of experts for the study of economic aspects of water pollution control problems the characteristics of waste waters from the manufacture of viscose rayon fibres were outlined. These comprise acidic and alkaline streams which when mixed result in an acidic solution in which α and β celluloses are regenerated and may be settled after flucculation. The efficiency of flocculation is influenced by temperature and concentration of sulphuric acid and sodium sulphate; sedimentation improves at higher temperatures but is adversely affected by the presence of gas bubbles and by changes in atmospheric pressure.

ZINC RECOVERY FROM VISCOSE RAYON EFFLUENT. Aston, R. S.; Ont. Ind. Waste Conf., Proc. No. 13, p. 215-230, (1966).

The recovery of Zn, in the form of $ZnSO_4$, by ion exchange was successfully applied to the treatment of effluent liquors from a viscose rayon plant. The resin used was Permutit Q, a cation exchanger of the sulfonated polystyrene type, operating in the H cycle and regenerated with H_2SO_4.

REMOVAL OF ZINC FROM WASTE WATERS FROM VISCOSE FIBER PRODUCTION, Fishman, G. I.; Mater. Soveshch. Molodykh Spets. Vses. Nauch. Issled. Vodosnabzh. Kanaliz. Gidrotekh. Sooryzhennii Inzh. Gidrogeol. Ochistka Stochn. Bod., Moscow, p. 9-15, (1966), (Russian).

A soda-sulfate method is recommended for local clarification of concd. Zn-contg. waste waters if complete Zn removal is necessary; if the latter is not required, a soda method is recommended and regeneration of the Zn is not expedient. In the soda-sulfate method a Na_2Co_3 soln. is added to the waste waters to pH 4-4.5; after blowing with CO_2 in a degasifier the pH is brought to 8.5-9.5. The $Zn_3SO_3(OH)_4$ formed is pptd. in vertical settling tanks. Then the waste waters are subjected to final Zn removal with Na_2S followed by filtration on sand filters (Filtration rate 5 m./hr.).

COMPOSITION AND CLARIFICATION OF WASTE WATERS FROM A SYNTHETIC FACTORY, Gantsmakher, Z.; Dokl. Neftekhim. Sekts., Bashkir, Respub. Provl. Vses. Khim Obshchest., 2, p. 143-145, (1966), (Russian).

Before discharging into the river the clarified waste waters pass through 2-step biol. ponds. The indexes of waste waters discharged from the clarifying equipment and of the river water 1 km. below the discharge point are: BOD 4.12, 6.03; Oxidizability 9.4, 8.24; caprolactam concn. 0.9, 0.16; dissolved 0 11.39, 7.37 gm./1/. resp.

ELECTROLYTIC REMOVAL OF COPPER FROM WASH WATERS FROM THE PRODUCTION OF RAYON BY THE CUPRAMMONIUM PROCESS, Haake, G. Neue Huette, II, (5), p. 272-278, (1966), (German).

Effects of copper concentration, sulphuric acid concentration, and temperature have been investigated.

COMPOSITION AND PURIFICATION OF WASTE WATER FROM CAPROLACTAM PRODUCTION, R. A. Kiseleva and M. S. Dudkin; Khim. Prom. 42 (10), 743-5 (1966), (Russian).

The waste analysis revealed that the aq.-acid layer contained 55% and the alk. waste water 43% of the total amt. of dicarboxylic acids. Two methods were developed for the purification of alk. wastes. The 1st (giving no pos. results) involved the use of adsorbent carbons: type A, iodized KAD, and milled KAD. In the 2nd, the alk. waste water was treated with coned. H_2SO_4 in amnts. allowing the clarified soln. to attain the acidity of 0.3N H_2SO_4. The soln. was then biol. purified or distd. with steam (removal of monocarboxylic acids and traces of cyclohexanol), and as result a soln. was obtained appropriate for yeast production.

CHOICE OF THE TYPE OF MIXING UNIT FOR PURIFICATION OF VISCOSE-PRODUCTION WASTE WATERS, Mal'kov, V. A.; Khim. Volok., (5), p. 57-59, (1966), (Russian).

The design of mixing chambers for the combination of milk of lime and effluent is discussed.

PURIFICATION OF EFFLUENTS FROM THE MANUFACTURE OF VISCOSE, V. S. Morgenshtern Ya. Z. Sorokin Yu. E. Matuskov and V. A. Mal'kov (Branch All-Union Res. Inst. Fibers, Leningrad). Khim. Volokna (1966), (1), 44-7, (Russian).

Pilot plant expts. were carried out in order to det. the best method of pptg. Zn from viscose effluents and of removing the suspended particles. For effluents from rayon fiber manuf., lime was the best pptg. agent. Complete pptn. of Zn takes place at pH 9.5-10.5. Subsequent 2-step sedimentation gives a high degree of effluent purification. When the recovery of Zn from the effluent is recommended, e.g. in the manuf. of rayon cord fibers or reinforced textile rayon fibers, pptn. of Zn with calcined soda and then with Na_2S is preferred. The Zn is recovered from the sedimented ppt. by treatment with H_2SO_4 in a yield of about 90%.

CLARIFICATION OF SEWAGE FROM SYNTHETIC FIBER FACTORIES WITH THE AID OF SINGLE-CELL ALGAE, Palamar-Mordvintseva, G. M.; V. K. Marinich, V. V. Grabovs'ka, and S. M. Neigauz; Ukr. Botan. Zh., 23, (5), p. 56-61, (1966), (Ukrain).

Expts.were conducted in open basins to confirm data obtained under lab. conditions on the possibility of cultivating Chlorella algae on sewage from synthetic fiber production for the purpose of clarifying the sewage. Growth and development of algae and clarification of sewage were more rapid under natural conditions than in the lab. The main clarification was completed in 1 day in the presence of algae. A 3-day cultivation of the algae removed Zn, H_2S, S, and sulfides (100%) and CS_2 (60%), and decreased BOD by 92.5%.

USE OF SEWAGE FROM HYDRAULIC ASH REMOVAL FROM POWER PLANTS FOR NEUTRALIZATION AND FINAL CLARIFICATION OF SEWAGE FROM VISCOSE FIBER PRODUCTION, Pleshakov, V. D. and Matsrev, A. I.; Tr. Novocherk. Politekhn. Inst. (USSR), 157, 29 (1964); Chem. Abs., 65, 3551, (1966).

The author studied the use of an ash waste from a power plant to neutralize and clarify waste from a synthetic fiber operation.

VISCOSE RAYON WASTES AND ZINC RECOVERY THEREFROM, Saxena, K. L., and R. N. Chakrabarty; Technology (Sindri), Spec. Issur. 3 (4), p. 29-33, (1966).

To avoid fouling and choking the sewers, acidic and alk. wastes are sepd. Most of the Zn in the spent spinning soln. can be recovered by neutralization, thus reducing the toxicity of the wastes.

VISCOSE RAYON FACTORY WASTES AND THEIR TREATMENT, Sharda, C. P. and K. Manivannan; Technology (Sindri), Spec. Issur. 3 (4), p. 58-60, (1966)

The process of viscose rayon manuf. is briefly described. The effluents from the factory are classified as alkali, viscose, acid sulfide, and sanitary. The combined waste treatment may be difficult and sep. treatment is recommended. The process adopted includes neutralization and settlement, incineration, neutralization with lime or limestone and trickling filter. The addnl. problem of Zn removal from viscose tire cord factory is mentioned.

AERATION, SETTLING, AND CHLORINATION OF THE COMBINED WASTE FROM A VISCOSE FIBER PLANT, Sinev, O. P.; Tr. Novocherk. Politekh. Inst., 162, p. 33-43, (1966), (Russian).

Treatment of waste waters in an aerator with an air rate of 10-10.4 m.^{3}/m.^{3} waste water reduced the CS_2 concn. from 41.6-82.3 to 5.2-9.0 mg./l., and H_2S from 13.7-26 to 1.45-3.1 mg./l. Combined pptn. of suspended solids at pH $\geq$10 ensured not only intensive floccule formation and pptn. of hydrocellulose but also better conditions for extn. of Zn $(OH)_2$. Chlorination was most effective for a supplementary clarification after lime treatment and removal of suspended solids. The Cl absorbability of the waste waters after lime treatment, settling, and filtering through a sand filter was 46-73 mg./l. Residual CS_2 and H_2S concns. in the waste waters at Cl_2 doses equal to Cl absorbability were 5.3-12.9 and 0-7.1 mg./l., resp. A preliminary aeration of the waste waters at pH 3 considerably reduced Cl absorbability.

REMOVAL OF ZINC FROM SEWAGE, Skylev, T. D.; Zhur. Priklad. Khim. (USSR), 39, 544 (1966), Chem. Abs., 65, 1950, (1966).

A study of zinc removal that found that in an acid solution Na_2S treatment to excess, then $FeSO_4$ to excess would precipitate the zinc. If the waste was alkaline, then adjust to acid before adding Na_2S. The precipitate was then filtered to concentrate the zinc.

COMBINED CLARIFICATION OF WASTE WATERS AND VENTILATION EXHAUSTS IN VISCOSE FIBER PRODUCTION, Zakharina, S. B.; Mater. Soveshch. Molodykh Spets. Vses. Nauch.-Issled. Inst. Vodosnabzh., Kanaliz., Gidrotekh. Sooruzhemii Inzh. Gidrogeol., p. 79-83, (1966), (Russian).

A process for clarification of waste waters and ventilation exhausts was developed. The latter, contg. H_2S, enter a hollow steel scrubber wet with a soln. of calcined soda (30-75 g./1.). The purified gases contg. $\leq$ 20 mg. $H_2S/m.^3$ are released into the atm. Waste waters contg. $ZnSO_4$ and H_2SO_4 entered a mixer where the pH is brought to 4-5 with a soda-sulfide soln. To remove CO_2 formed the waste waters are passed to a packed degasification column to which air is fed (0.2 m./sec.). ZnS is removed, dehydrated in a vacuum filter, and calcined in the presence of atm. O (Sulfatizing calcination furnace) to obtain $ZnSO_4$.

APPLICATION OF THE BASIC PRINCIPLES OF BIOLOGICAL ACTIVATED-SLUDGE TREATMENT TO THE TREATMENT OF WASTE WATERS FROM "CHEMLON" MANUFACTURE, Zekeova, Z. N.; - Pr. vysk. Ust. vodohospod., Bratislava, (1966) No. 40 78 pp.

Investigations were carried out on the waste waters from the processing of 6-caprolactam to produce polyamide fibres of the "chemlon" type, and data are reported on the sources, volume, and composition of the waste waters (excluding cooling water, which is not treated) and on the parameters required for design of an activated-sludge plant to treat the waste waters, including optimal loading and detention period, concentration of activated sludge, nutrient requirements and intensity of aeration. Activated sludge from municipal sewage was acclimated satisfactorily to treat waste waters containing up to 600 mg. of caprolactam per litre but above this level the sludge developed undesirable properties. During the process there was a loss of nitrogen which increased with increasing concentrations of waste waters and with higher loadings, reaching a maximum of 56.7 percent; the loss of nitrogen decreased with higher concentrations of phosphate and was completely negligible with a nitrogen-phosphorus ratio of 2.1.

AN INDUSTRIAL WASTE GUIDE TO THE SYNTHETIC TEXTILE INDUSTRY. AATCC Comm. on Stream Sanitation Technol. Prepared in cooperation with the National Technical Task Comm. on Industrial Wastes. U. S. Public Health Serv., Wash. (1965).

This guide describes problems involved in the treatment of wastes from the synthetic textile industry and offers general treating methods.

CHIEF PRINCIPLES OF BIOLOGICAL OXIDATION OF SEWAGE FROM CELLULOSE PRODUCTION IN AERATION TANKS, M. A. Evilevich; Tr. Vses. Nauch.-Issled. Inst. Tsellyul.-Bum. Prom. No. 51, 43-62 (1965), (Russian).

In the load range 118-542 mg./g.-day the concn. of activated sludge had no effect on the rate and effectiveness of clarification. A decrease in the sewage temp. to 10-13° also had no effect on these factors. To ensure a steady performance of equipment under low temp. conditions prolonged adaptation of microorganisms is necessary. The oxidative capacity of an aeration tank is directly proportional to the amt. of air used (in the range 28-64 m.^{3}/m.^{3} tank vol.). Aeration tanks perform efficiently at oxidative capacities of 1500-1600 g./m.^{3}/day for sewage from sulfite pulp production and 1000-1200 g./m.^{3}/day for sulfate pulp sewage. In planning, oxidative capacities of 1200 and 800 g./m.^{3}/day and aeration time of $\geq$5 hrs. are recommended. The air consumption is calcd. by the formula $D = 1.430\ C/KH$, where OC is the oxidative capacity, K is the air consumption coeff., and H is the depth of immersion of the aerator. The effective dose of activated sludge is detd. ensuring a load on the sludge of 400-500 in the summer and 200-50 mg./g.-day in the winter. The concn. of activated sludge was $\geq$ 3 g./l. The consumption of biogenic elements was calcd. from the ratio 5-day BOD: N:P = 100: 4:1.

THE PURIFICATION OF VISCOSE-CONTAINING WASTES BY THE ACTIVATED SLUDGE PROCESS, Kaeding, J.; and L. Erdtel; Fortschr. Wasserchem. Ihrer Grenzgeb., 3, p. 212-216, (1965), (German).

Neutralization and pptn. of dissolved org. material in cellulose waste water leaves behind about 500 population-equivs. (5-day BOD)/ton. Preliminary expts. show that it is possible to reduce this 90% by further biol. treatment.

USE OF CLARIFIERS WITH A FLUIDIZED/SEDIMENT FOR PURIFICATION OF SEWAGE FROM VISCOSE FIBER PRODUCTION, V. A. Mal'kov; Sanit. Tekhn., Dokl. k Nauchn. Konf. Molodykh Uchenykh Stroitelei, 1st, Sb., Leningrad (1965), 77-88 (Russian).

A slit-type clarifier with a removal sediment condenser exhibited several advantages over All-Union Sci.-Res. Inst. Hydrotech. and Sanit.-Tech. Works clarifiers and diffusers. The clarifier performed best at a rate of 1.4 mm./sec. in the fluidized layer zone and a % suction of 25-40%. Residual concns. of suspended solids and Zn in the clarified sewage were 40-73 and 3.2-6.0 mg./1., resp. Clarification was 86-94% and 84-91% for suspended solids and -Zn, resp.

USE OF CONTACT CLARIFIERS FOR THOROUGH CLARIFICATION OF SEWAGE FROM VISCOSE PRODUCTION CONTAINING SUSPENDED MATERIAL AND ZINC, Yu. E. Matuskov; Sanit. Tekh., Kokl. Nauch. Konf. Leningrad. Inzh.-Stroit. Inst., 23rd, Leningrad (1965), 90-3 (Russian).

The specific amt. of sewage formed in various productions is: viscose rayon 700-1500; cord 300-700; staple 300-500 $m.^3$/ton of product. The indexes of the total waste waters of the plant are: Zn^{++}10-100, $CS_2$2-40, H_2S 2-45, suspended solids 50-300, Na_2SO_4 1000-7000, chem. 0 demand 60-250, 5-day BOD 30-150, solid residue 1000-10,000, calcined residue 500-8000 mg./1., and pH 1.5-12.0. A method for removing Zn^{++} with the aid of lime (at pH 9.0-10.5) was developed. A pilot app. consisted of a mixer, clarifiers, and settling tanks.

PILOT STATION FOR THE PURIFICATION OF THE RESIDUAL WATER IN THE PULP, PAPER, AND ARTIFICIAL FIBER INDUSTRIES, Stanescu, N. and V. Sirbu; Celuloza Hirtie, 14, (1), p. 27-30, (1965), (Rumanian).

A pilot station for the purification of the residual water in the pulp, paper, and artificial fiber industries in Roumania is described. The purification is first performed phys.-chem. (neutralization, coagulation, decantation) and then biol. (strong agitating with compressed air, biofiltration).

DIMETHYLFORMAMIDE IN BIOLOGICAL PURIFICATION OF WASTE WATER, M. Thonke and W. Dittmann; Fortschr. Wasserchem. Ihre Grenzgeb 4: 272-277, (1966), (German) Through Chm. Abstr. 67, No. 8: 36195, 1967.

Dimethylformamide, present in the waste water from acrylic fiber production, is relatively quickly degraded by an activated sludge treatment and provides a source of carbon and nitrogen.

DYE WASTE TREATMENT

ACTIVATED CARBON RECLAIMS TEXTILE INDUSTRY'S WASTE WATERS, Environmental Sci. & Technol. 3: 314-315, (Apr. 1969).

> Eighty percent of the process waters for dyeing and rinsing operations can be reused by effluent treatment with carbon reactivation in Calgon's Filtrasorb waste water reclamation system.

WILL SOLVENT DYEING SOLVE WATER POLLUTION PROBLEM?, Atlantic News 5: 1, 3, (Nov. 1969).

> A solvent dyeing system together with efficient recovery of solvent is a solution to the problem of water pollution from the discharge of dye wastes into streams.

THE TREATMENT AND CONTROL OF BLEACHING AND DYEING WASTES, A. H. Little; Water Pollution Control 68, No. 2: 178-189, (1969) Through World Textile Abstr. 1: 2640, (1969).

> The composition of typical textile waste liquors is described. Neutralization of alkaline kier liquor with sulfuric acid or with flue gases is discussed. Sedimentation may not always be necessary. Biological treatment in experimental activated sludge plants of bleaching and dyeing liquor is described. There was no pronounced difference in the performance of mechanical aeration and diffused air plants.

ACTIVATED SLUDGE PLANT FOR DYEING WASTE WATERS, Effluent Water Treatment J. 8: 355, (1968) Through Water Pollution Abstr. 42: 820, Apr. 1969.

> An activated sludge plant which treats waste waters from the dyeing of synthetic yarn and wool at the mills of John Shaw and Sons Ltd., is described. The 2 aeration tanks, which can be run in series of in parallel, are equipped with Cavitair surface aerators. The waste water is treated to comply with the Royal Commission standards specified by the Yorkshire House and Hull River Authority, and the effluent is discharged to the river Calder.

WATER: A PROBLEM AND A PROMISE, Monsanto Mag. 48: 10-13, (Oct. 1968).

> This article is an account of how Monsanto Biodize Systems is providing a practical, low-cost approach to reducing water

pollution at Cold Springs Bleachery, a Pennsylvania plant involved in several cotton finishing operations. The process is based on the biological oxidation of organic pollutants.

THE CENTRAL WASTE-TREATMENT PLANT OF THE PETROCHEMICAL AND DYE MANUFACTURE WORKS OF BAYER, A. G., AT DORMAGEN, Jubermann, O., and Krause, G.; Chemie-Ingr.-Tech., (1968), No. 6, 288-291.

Details are given of the operation and efficiency of the waste treatment plant of Bayer, A. G., in Dormagen, Germany, where the waste waters from the chemical and petrochemical industry are treated biologically, using ejector aeration which through maintaining a favourable oxygen supply has proved satisfactory.

WATER FOR THE DYER. PART 1., T. H. Morton (Courtaulds Ltd.), Textile J. Australia 43: 16-19, (Nov. 1968).

The present and estimated future use of water in England and Wales is compared with available resources. The changes in procurement of water and disposal of effluent implied in recent legislation are discussed, particularly as they are likely to affect the dyeing industry. The quality of water for use in the dyeworks is discussed in terms of dissolved and suspended impurities; and the methods available for the control of the effects on the dyeing process of ionic solutes, residual hardness, heavy metals, and bicarbonate are summarized.

WATER FOR THE DYER. PART 2., T. H. Morton (Courtaulds Ltd.), Textile J. Australia 43: 40-44, 52, 54, 60, (Dec. 1968).

In this part, the author covers the quality of water for use in dyeworks, technical effects of water solids, and effluents from dyeworks in relation to water policy in Great Britain. The overall purpose of this paper is to show that the water supply can no longer be taken for granted and that dyeworks should carefully consider their use and disposal of this decreasing resource.

ENERGY-INDUCED CHANGES IN AN AZO DYESTUFF WASTE, A. I. Mytelka (Ritter Pfaudler Corp.) and R. Manganelli (Rutgers Univ), J. Water Pollution Control Fed. 40, No. 2, Part 1; 260-268, (Feb. 1968).

Sterilization of water and wastewater by means of radiation is based on energy-induced changes in the waste and the effect of these changes on subsequent biological oxidation. The industrial waste selected for testing was an azo dyestuff mother liquor with low biodegradability and intense color. The ionizing radiation source was cobalt-60 gamma rays. Parameters investigated include total organic carbon (TOC), COD, BOD, dye concentration, color, solids, and pH. Results show a decrease in the above variables, and a waste more amenable to biological oxidation as radiation dosages increased.

DISPOSAL OF DYE AND FINISHING HOUSE WASTES AND SIMILAR MATERIALS, E. C. Oden; Water Sewage Works 114: 367-368, 1967. Through Water Pollution Abstr. 41: 1504, (Aug. 1968).

The author discusses the design and operation of systems for the disposal of dyeworks waste waters. His recommendations include the use of a holding tank with a retention period long enough for fibers to be removed from the liquid surface and the construction of covered trenches filled with limestone and sand to receive waste waters before discharge to surface water.

RECOVERY OF HEAT FROM LIQUID EFFLUENT IN DYEHOUSES, F. O. E. Schwenkler, Spinner Weber Textilveredlung 86, No. 8: 705, (1968), (German) Through Shirley Inst. 48: 4497, (1968).

It is estimated that half the heat energy in hot dyeing liquors can be recovered: the heat exchanger is shown diagrammatically.

THE QUANTITY AND COMPOSITION OF WASTE WATER FROM A HOSIERY MILL, Spivakova, O. M.; Neimark. G. I.; Krasnoborod'ko, I. G. (Leningrad Inzh.-Stroit. Inst., Leningrad, USSR), Tekst. Prom (Moscow), (1968), 28(6), 71-2, (Russian).

Waste waters were analyzed from a large knitting and hosiery mill in Leningrad where scouring, bleaching, and dyeing is done; 11,000 $m.^3$ of waste water/24 hrs. is discharged into the city sewers from this mill. It is recommended that waste water should be decolorized, purified from surface-active materials to a certain level, and then be dild. with city sewage and treated by aeration on city's sewage plant.

PRELIMINARY WORK FOR A JOINT SEWAGE-TREATMENT PLANT FOR THE DYEWORKS OF BAYER A. G. AND THE WUPPERVERBAND, Weber, H. H. and Mersch. F. Chemie-Ingr-Tech., (1968), No. 6, 272-274.

Following extensive pilot-plant experiments to find the most efficient treatment for the waste waters of Bayer's chemical works which contain a heavy load of organic substances, it was decided that these waste waters should receive full biological treatment in the joint sewage-treatment plant of the Wupperverband. Those containing weak acids will be discharged to the North Sea together with the effluents from a titanium works. The waste waters from both industries containing inorganic substances should first be sufficiently diluted with cooling or rain water before they are discharged to the Rhine.

POLAROGRAPHIC DETERMINATION OF NITRO COMPOUNDS IN WASTE WATERS FROM THE ANILINE DYE INDUSTRY, Zaitsev, P. M.; Krasnosel'skii, V. N.; Dichenskii, V. I. (USSR), Zavod. Lab., (1968) 34(8), 940-1, (Russian).

This method is particularly applicable to waste waters contg. p-nitrophenetole, o- and p-nitroanisole, and aminonitrocresol. Into a 15 ml. flask, place 1-30-g. sample of waste water, 15 ml. MeOH, a definite vol. of 10N NaOH, 0.5 ml. of 0.5% gelatin soln., and H_2O to mark. Stir, remove dissolved O, and analyze in a polarograph. The $E_{1/2} = 0.75-0.80$ v. indicates the content of nitroanisoles and nitrophenetoles and the $E_{1/2} = 0.98-1.05$ v. the content of nitrophenols. In the anal. of waste waters from the production of aminocresol contg. up to 1 g./1. of 3-nitro-4-cresol the error does not exceed 4%.

PERFORMANCE OF PLASTIC FILTER MEDIA IN INDUSTRIAL AND DOMESTIC WASTE TREATMENT, Chipperfield, P. N. J.; J. Water Pollution Control Fed., 39, p. 1860-1874, (1967).

In Great Britain, a plastic medium for packing trickling filters has been developed and tested with domestic and industrial wastes, including textile dyeing and finishing wastes. The medium (Flocor), consisting of alternate plain and corrugated sheets of polyvinyl chloride, is said to be inexpensive and efficient.

TREATMENT OF INDUSTRIAL WASTE. VI. TREATMENT OF SULFUR DYE WASTE, 4. Ichikawa, Kunisuka; Maeda, Yoshimichi (Himeji Inst. Technol., Himeji, Japan), Himeji Kogyo Daigaku Kenkyu Hokoku, (1967), 20A 91-6 (Japan).

The waste stack gas, contg. 10% CO_2, was successfully used to neutralize the alk. S dye waste. It is necessary to remove Na_2S by oxidn. provided the waste contains considerable amts. of Na_2S. After the neutralization, the waste can be clarified either by the addn of $FeSO_4$ or the electrolytic treatment applying 1-10 v.d.c. Though the electrolytic treatment is efficient and economical, further investigation on the electrode problems is required.

CLARIFICATION OF WASTE WATER CONTAINING DYES. III. PRECIPITATION OF DIRECT DYES AND ACID DYES BY IRON SALTS, Iida, H., and Endo, M.; Rep. Govt chem. ind. Res. Inst., Tokyo, (1967), 62, 134-138; J. appl. Chem. Abstr., 1968, 18, i.333.

Studies on the treatment of dyeworks waste waters by coagulation with iron salts showed that treatment with 80 p.p.m. ferric iron, as ferric chloride, removed 96 percent of the direct dyes and 60 percent of the acid dyes from a 100 p.p.m. solution; addition of sodium sulphate reduced the removal of direct dyes slightly and hindered the removal of acid dyes. Treatment with ferrous sulphate, with adjustment of the pH value to about 10, removed 92 percent of the direct dyes and 36 percent of the acid dyes; again the removal of the dyes was adversely affected by addition of sodium sulphate and sodium carbonate.

PRECIPITATION OF DIRECT DYES AND ACID DYES BY IRON SALTS, H. Iida and M. Endo (Govt. Chem. Ind. Research Inst., Tokyo); Kogyo Kagaku Zasshi 70: 403-404, (1967).

In order to obtain basic data for the clarification of industrial waste water containing dye, 18 direct dyes and six acid dyes were precipitated from each aqueous solution by the addition of ferric chloride or ferrous sulfate, and the amounts of precipitated dyes were determined. From the results it was found that ferric chloride and ferrous sulfate were excellent for the precipitation of direct dye, but were not useful for acid dye. It was difficult to precipitate acid dyes from their aqueous solution containing sodium sulfate by the above method.

TREATMENT OF SULFUR DYE WASTE WATERS, V. OXIDATION OF SODIUM SULFIDE BY OXYGEN, Maeda, Yoshimichi; Nishiumi Yoshio; Ichikawa, Kunisuke (Himeji Tech. Coll., Himeji, Japan); Kogyo Yosui, (1967), No. 106, 60-7 (Japan).

Aq. solns. of $3.3-12.8 \times 10^{-2}M$ Na_2S were used as samples of sulfur dye waste water. A sample soln. (327 ml.) was placed in a modified Ziegelmeyer's vessel (1958) and agitated at 500 rpm. under 1. atm. O. The oxidn. rate of Na_2S by O was observed at 20° without or with existence of various materials such as 12 sulfur dyes, 2 sulfur vat dyes, 8 vat dyes, $CuSO_4$, $CoSO_4$, $FeSO_4$, pyrocatechol, sulfate lignin, and treated mud of town sewage. Among these materials, sulfur dyes, sulfur vat dyes, sulfates except $FeSO_4$, pyrocatechol, and some vat dyes such as Threne Briliant Blue 4G and Threne Khaki GG accelerated greatly the oxidn. of Na_2S in a concn. of 0.5-1 g./1. Oxidn. products were salts of S_2^{2-}, SO_3^{2-}, and mainly $S_2O_3^{2-}$. The treated mud and sulfate lignin were also good accelerators for the oxidn. of Na_2S.

RADIATION TREATMENT OF AN INDUSTRIAL WASTE, Mytelka, Alan I.; Manganelli, Raymond M. (AeroChem Res. Lab., Inc., Princeton, N. J.); Purdue Univ., Eng. Bull., Ext. Ser., (1967), No. 129 (Pt. 2), 1025-43.

Current biol. waste treatment methods are often unsatisfactory because many effluents are refractory to biol. oxidn. This is a study of radiation-induced changes in an industrial waste and the effect of these changes on the biol. degradation of the waste. An azo dye mother liquor was selected. Under conditions of the investigation chm. 0 demand (C.O.D.) of the waste was reduced 61%, total org. C 43%, and for all practical purposes no dye remained. The waste also became more amenable to biol. oxidn. with the redn. of the COD/BOD ratio from 54 to 2.2.

EFFLUENTS FROM DYEING AND FINISHING BATHS, Peyron, E.; Teintex, 32, (6), p. 419, 421-422, and 425, (1967), (French).

The treatments of dyeing and sizing effluents used in the textile industry were discussed. The autoneutralization, pH regulation, flocculation, decolorization by C and decantation processes involved were described. The various effluents were combined in an equilization bath provided with a surface skimming device and an aeration system by compressed air. Flocculation is carried out by $Al_2(SO_4)_3$ and Na silicate in a special tank. $CaCl_2$ used for decolorization is distributed automatically and is controlled by a galvanometric device.

FOR LYMAN: A $2 MILLION POLLUTION SOLUTION, F. Rigsbee; Textile Bull. 93: 49-50, (Feb. 1967).

The industrial waste treatment plant at Lyman Printing and Finishing Co. is described.

POLAROGRAPHIC DETERMINATION OF TRIAZINE AZO DYES, Shkorbatova,

T. L. and L. D. Pegusova; Zh. Anal. Khim., 22, (6), p. 918-923, (1967), (Russian).

> The polarographic behavior of some triazine azo dyes and amino azo dyes in certain universal buffer solutions (Britton-Robinson) was studied. One of the dyes, Violet 4K, contained Cu and one Cl in the triazine group, all the other belong to the dichlorotriazine dyes. All dyes give polarographic waves in the pH range 2-10. The height of all polarographic waves of all dyes studied is linearly proportional to the concentration of the substance determined. The above properties can be used for the polarographic determination of dyes in stationary waters and sewage. The absence of a second wave on the polarograms proves that the active dyes are present in sewage in a hydrolyzed state. The accuracy of the method was studied by adding known amounts of dyes. The relative error is +/- 2.85%.

ACTIVATED SLUDGE TREATMENT OF SOME ORGANIC WASTES, Wheatland, A. B. (Water Pollut., Res. Lab., Stevenage, Engl.); Purdue Univ., Eng. Bull., Ext. Serv. (1967), No. 129 (Pt. 2), 983-1008 (English).

> Activated sludge can be used to treat waste waters from a variety of industries if conditions are provided for the microorganism to become acclimatized to the wastes. Waste waters contg. potentially toxic or inhibitory org. substances which are only slowly degraded by microorganisms even after a period of adaptation may require diln. If domestic sewage is used as a diluent, it may facilitate treatment by providing nutrients and required trace elements. Activated sludge becomes acclimated to waste waters from the production and dyeing of synthetic fibers more rapidly when the proportion of waste water in the sewage is increased in stages. A period of about a month should be allowed for acclimatization. Increase in temp. can be beneficial but performance at 30° is not greatly superior to that at 20°. Waste water from a dyehouse and from the manuf. of synthetic rubber can be treated in the absence of domestic sewage. Color in the dyehouse effluent required coagulation with alum followed by settling for removal. Partial purification of the waste water from a dairy products factory is possible by contact stabilization providing bulking of the activated sludge can be prevented.

AERATED LAGOON HANDLES 10-MILLION BPD., Textile World 116: 86-87, (Feb. 1966).

> The aerated lagoon of Springs Cotton Mills' Grace Bleachery is briefly described.

METHODS FOR REMOVING SULFUR DYES FROM WASTES FROM THE DYEING PLANT OF THE V. I. LENIN BAKIN TEXTILE WORKS, Akhmedov. K. M. and I. M. Garibov; Tekh. Progress, (5), p. 41-43, (1966), (Russian).

Experiments were made with wastes containing 600 mg./1. sulfur dyes. A 10% H_2SO_4 solution (250-750 mg./1./) and 0.1% solution of polyacrylamide (2mg./1.) were added to the sewage, stirred 2 minutes, and left to settle for 0.5 hr. The residual concentration of sulfur dyes was 0-100 mg./1.

CARPET MANUFACTURING EFFLUENTS AND THEIR TREATMENT, D. Evers; J. Proc. Inst. Sewage Purif. Part 5: 464-470, (1966) Through Shirley Inst. 46: 5941, (1966).

Carpet processing effluent is divided into categories - effluent from (1) scouring of raw wool and yarn, (2) dyeing, (3) sizing, (4) latexing, (5) moth-and mildew-proofing. If a firm discharges all these effluents, the smaller volumes of effluent from latexing and proofing will be lost in the larger volumes from scouring and dyeing. If only dyeing and latexing are carried out, acid dye liquors will precipitate latex and clog the sewers. Acidity in dye liquor could be used to reduce the acid needed in treatment of fatty scouring effluent, but the increased volume of liquor to be treated would be uneconomic to process as scouring liquor. The scouring liquors have a high biological oxygen demand; dyeing liquors can be put to better use as diluents for the outflow from the grease cracking plant.

BIOLOGICAL TREATMENT SOLVES DYEWORKS EFFLUENT PROBLEMS, Felstead, J. E.; Wat. Waste Treat. J., 11, p. 127-129, (1966).

A description is given of the development of treatment facilities for waste waters from the textile dyeing and finishing plant, which involved preliminary chemical analyses of a considerable number of minor effluents and laboratory-scale trials on composite effluents. The waste waters were formerly passed over alumina ferric blocks and settled before discharge, but the effluent failed to comply with the standards laid down by the Trent River Authority. The waste waters from the 2 mills, in nature mainly organic, but also containing low concentrations of a variety of other compounds such as inorganic salts and bases, are not pumped first to a holding tank, and then to 2 activated-sludge tanks fitted with Simcar aerators.

MILL SUPPLY WATER IN FINISHING, H. Gunther; Spinner Weber Textilveredlung

84, No. 8: 858-863; No. 11: 1255-1258, (1966), (German) Through Shirley Inst. 46: 6653, (1966).

> The required purity levels and test methods are summarized. Corrective measures and normal volume requirements in finishing are specified.

A DYER'S "OPERATION CLEANUP", S. M. Suchecki; Textile Inds. 130: 113-126, 136, 185 (June 1966).

> Waste treatment and water pollution control are discussed and the program of Northern Dyeing Co. is described.

PURIFICATION OF WASTE WATER FROM DYEING AND FINISHING OPERATIONS, Vasil'ev, G. V. (USSR), Tekst. Prom. (Moscow), (1966), 26(7), 52-4, (Russian).

> Waste water of heterogeneous compn. (suspended matter 150-250, dry substance 1000-1500, COD (Chem. 0 demand) 250-1200, BOD, 100-400, synthetic detergent 30-130, Cr. 0.1-0.5 mg./1.) from dyeing and finishing operations is purified by aeration in activated sludge. For the biol. purification, the H_2O is treated with Cl_2 or O_3.

PURIFICATION OF WASTE WATERS FROM DYEING AND FINISHING FACTORIES, Vasil'ev, G. V.; Tekstil. Prom., 26, (7), p. 52-54, (1966), (Russian).

> Problems associated with the ever-increasing use of new dyes, synthetic surface-active agents which cause excessive foaming, and of finishing agents such as dodecylbenzene-sulphonate, certain cationic agents, and Karbozolin which can be oxidized biochemically to only a small extent and are toxic to microflora used in effluent purification, are discussed.

TREATMENT OF INDUSTRIAL WASTES, Wagner, H. O. and Souther, R. H.; Southern Engineer, Vol. 84, p. 37, (1966).

> Description of the Canton, Georgia waste treatment plant which handles waste consisting of 52% domestic sewage and 39% textile dyeing and finishing wastes and 9% hospital wastes.

CLARIFICATION OF WASTE WATERS FROM PRODUCTION OF ACTIVE TRIAZINE DYES, Zakhorzhevskaya, A. G.; Vodosnabzh. Kanaliz. Gidrotekh. Sooruzh. Mezhved. Resp. Nauch. Sb., (1), p. 37-46, (1966), (Russian).

A flow sheet is proposed. After concn., the waste waters enter the cathode space of an electrolytic bath where they are reduced for 12-14 hrs. at c.d. 8 amp./dm.^{2}. Dyes and org. impurities are decompn. products are pptd.; the waste water loses its color. NaOH formed by electrolysis is recovered.

DETERMINATION OF CHLORIDE IONS AND 2, 4-DINITROCHLOROBENZENE IN SEWAGE FROM SULFUR DYE PRODUCTION, Khr. Popov. Khim. Ind. (Sofia) 37 (5), 164-8, (1965), (Bulg.).

In the absence of 2,4-dinitrochlorobenzene (I), Cl^- is detd. by dilg. a 5-10 ml. sample with distd. H_2O, a sufficient amt. of 0.1N $AgNO_3$ is added for the complete pptn. of chlorides, sulfides, polysulfides, sulfites, and thiosulfates, plus 2-3 ml. excess, an amt. of HNO_3 is added equal to 0.5 the vol. of the test soln., glass beads are added, and the mixt. is boiled for 4-5 min. If the soln. is not completely colorless, 20-30 ml. dil. HNO_3 (1:2) is added, and the soln. re-boiled. After cooling to room temp. the soln. is filtered to remove AgCl, and the ppt. is washed to a neg. Ag reaction with very dil. (0.02-0.05N) HNO_3. The filtrate and wash waters are combined, and the detn. is completed by using Folhards method, where the excess $AgNO_3$ is titrated with 0.1N NH_4SCN, using $FeNH_4(SO_4)_2$ as indicator to a rose-red color. Where I is present total Cl^- is detd. by boiling the sample with 8% NaOH in order to transform molecular Cl in I to Cl^-, and the analyses completed as above. A sep. analysis for Cl^- without this transformation give Cl^- content without the mol. Cl from I, and the amt. of I can therefore be calcd. by difference.

ACTIVATED-SLUDGE TREATMENT OF TEXTILE AND DYEING MILLS WASTE, Kashiwaya, M.; Proc. 2nd Intern. Conf. Water Pollution Research, Tokyo, 2, p. 63-84, (1965).

In the region of Ichinomiya, Besai, and Kosogawa, Aichi Prefecture, Japan, waste waters from 129 factories processing, dyeing and finishing textiles have caused serious pollution of the Nikko River. The author reports pilot-scale studies, with tabulated and graphical results, which showed that the waste waters could be treated effectively by a conventional activated-sludge or contact-stabilization process.

DISPOSAL OF EFFLUENT, D. W. Hill (Shirley Inst.), Textile Weekly 65 (2): 841-842, (Nov. 1965).

The activated sludge method of biological treatment of disposing of dyeing and finishing wastes, as applied by the Shirley Institute, is outlined. Mention is also made of the use of water-conserving washing procedures to reduce both the amount of water used and the volume of effluent.

EFFLUENT TREATMENT IN DYEWORKS, Shirley Inst. Intern. Dyer 134: 871-873, (Dec. 1965).

A brief review of the work reported by the Shirley Institute in leaflets and at the open-days of the Cotton, Silk & Man-Made Fibres Research Assoc. on effluent treatment studies.

RESEARCH ON METHODS FOR THE DECOLORIZATION OF DYEWORKS WASTE WATERS DISCHARGED INTO RIVERS, Weiner, L.; Munteanu, A.; Iancu, A.; Gafiteanu, M.; Negoescu, V.; and Malacea, I.; Trib. CEBEDEAU, (1965), 18, 440-445.

Pilot-scale studies have been carried out on the treatment of waste waters from a factory manufacturing dyes in Romania. It is now concluded that the waste waters should be equalized for a period of 24 hours and oily products should be removed in a separator before the physico-chemical treatment. Best results are obtained by treatment with 1.5-3 g of ferrous sulphate per litre followed by neutralization with 0.5-1 g of lime per litre, and sedimentation in a sludge- blanket tank with a surface loading of 0.5 m^3 per m^2 hour. The sludge produced has a moisture content of 99 percent which can be reduced by 80 percent in 5 days by a sand filter. After sedimentation, the best treatment was found to be filtration of effluent through active carbon at a rate of 5 m per hour (the cycle lasting 50 hours before regeneration of the carbon by heating anaerobically at 600°-700° C). This treatment not only decolorized the waste waters completely and reduced the oxygen demand by 80 percent, but also reduced the toxicity. Biological treatment of the settled waste waters was not effective owing to the low content of biologically-degradable organic material. To reduce the costs of treatment it is recommended that the different types of waste water should be segregated.

DETERGENT WASTE TREATMENT

EVALUATION OF DETERGENT PERFORMANCE, DISCUSSED, R. W. Moncrieff, Textile Weekly 69(1): 128-129, (Jan. 1969).

> This is a brief report of a conference on surface active substances in which 199 papers were presented. The search for a standard method of testing bio-degradability is the principle subject of this article.

USE OF AZURE A INSTEAD OF METHYLENE BLUE FOR DETERMINATION OF ANIONIC DETERGENTS IN DRINKING AND SURFACE WATERS, Den Tonkelaar, W. A. M.; Bergshoeff, G. (Res. Inst. Public Health Eng., TNO, Delft, Neth.), Water Res., (1969), 3(1), 31-8 (English).

> The methylene blue routine method, which is widely used for anionic detergents, is rather time-consuming and displays hardly satisfactory sensitivity for drinking water as well as pos. interferences by several substances. The Azure A method developed by van Steveninck and Riemersma (1966) proved to be more rapid, more sensitive, and more selective for detergents in drinking and surface waters.

DETERGENTS AND TREATMENTS OF CONTAMINATED WATERS, Argiero, L. and Paggi, A.; Hlth. Phys., (1968), 14, 581-592.

> Studies were made of the effect of surface-active agents on the treatment of waters contaminated with radioactivity, both by coagulation and by ion-flotation methods. Results are given for various cationic and anionic detergents and data are presented showing the effect of changes in pH value and in the electrostatic charge on suspended particles. In the ion-flotation method, a relation was found between the pH value, intrinsic viscosity, and efficiency of removal of caesium-137.

WATER POLLUTION AND SYNTHETIC DETERGENTS WHICH CAN BE BIODEGRADED, Revol, Louis (Fac. Med. Pharm. Lyon, Lyson, Fr.), Ses Parfums, (1968), 11(57), 35-46, (French).

> The article reviews basic detergent chemistry and structure, forms and effects of pollution, chem. and test of biodegradation, and synthesis of biodegradable detergents.

KNITTERS GUIDE TO BIODEGRADABLE DETERGENTS, Knitted Outerwear Times 37: 31-36, (Mar. 1968).

The table lists trade names, manufacturers, properties, and applications.

DETERGENT DEGRADABILITY, H. M. Lewis; Textile Forum 26: 15-39, (Feb.-Mar. 1968).

The problem of water pollution by bacterial resistant surfactants in detergent compositions, particularly alkylbenzene sulfonates, is discussed, and the development and chemistry of biodegradable linear alkylbenzene sulfonates and surfactants derived from secondary alcohols are reviewed. Methods of evaluating surfactant biodegradability are also covered.

BIOLOGICAL TREATMENT OF WASTE WATER FROM THE PRODUCTION OF ORGANICS, CONTAINING SURFACTANTS, AND DISPOSAL OF THE RESULTING EXCESS SLUDGE, Pitter, P.; Chudoba, J. and Palaty, J.; Sb. Vys. Sk. chem.-technol. Praze, Technol. Vod., (1968), 14, 27-46, (English).

Tabulated and graphical results are given of experiments on biological treatment of waste waters from the manufacture of organic chemicals; the waste water had BOD and COD values of 1000 and 2000 mg. per litre, respectively, and contained 21.5 mg. of anionic surface-active materials per litre of which 39.5 percent were not degradable. It was found that the waste waters could be treated by the activated-sludge process at an average loading of 940 g. of BOD per m^3 day and a detention period of 25.6 hours, when average reductions in COD and BOD of 55 and 85 percent, respectively, were obtained. If the effluent from the aeration tank was coagulated with alum, greater removal of the dispersed bacterial floc was achieved and the overall removals of COD and BOD were increased to 70 and 95 percent, respectively.

WATER AND WASTE WATER, M. Kehren; Z. ges. Textil-Ind. 69, No. 12: 937-942, (1967), (German) Through Shirley Inst. 48: 173, 1968.

This article relates specifically to consumption figures and recent legislation in W. Germany. There are notes on the poisoning of river life by detergents.

MICROBIAL OXIDATION ON SURFACE-ACTIVE AGENTS, Ray C. Allred and R. L. Huddleston (Continental Oil Co., Ponca City, Okla.), Southwest Water

Works J. 49(2), 26-8, 30, (1967).

The degradability was detd. on 14 surfactants by using river water and activated sludge in shake flasks and semi and continuous circulation. Branched chain structures are less susceptible to biol. attack than straight chain materials. The presence of a phenoxy group in the mol. will significantly retard biol. oxidn.

SURFACE-ACTIVE AGENTS IN TEXTILE PROCESSES AND THEIR EFFECT ON EFFLUENTS, Barnes, W. V., and Dobson, S. J.; Soc. Dyers Colour., (1967), 83, 313-320.

The widespread uses of surface-active agents in the textile industry, their biodegradability in relation to their chemical structure, and the difficulties which they cause at sewage works and in rivers are described and discussed. The necessary use of non-ionic detergents, which cause a great degree of pollution as a result of their resistance to degradation, is considered and their future improvement is mentioned.

BIODEGRADABLE SURFACTANTS FOR THE TEXTILE INDUSTRY, K. A. Booman, J. Dupre and E. S. Lashen (Rohm & Haas Co.), Am. Dyestuff Reptr. 56: p. 82-88, (Jan. 1967).

Test methods, biodegradability of anionic surfactants and of nonionic surfactants, field test results, and impact of government action are discussed.

BIODEGRADABILITY AND TREATABILITY OF ALKYL PHENOL ETHOXYLATES: A CLASS OF NONIONIC SURFACTANTS, Lashen, E. S.; Booman, K. A. (Rohm and Haas Co. Res. Lab., Spring House, Pa.), Water Sewage Works, (1967), 114 (Nov.), 155-63, (English).

In an activated sludge plant having 3 aerators in parallel, removal of OPE_{10} (Triton X-100), a nonionic surfactant, was > 90% at added influent concns. of 5 and 10 ppm., as shown by the $Co-(SCN)_2$ test of Crabb and Persinger (1964) and by loss of foaming and surface tension depressant activity. Concns. of OPE_{10} in the effluent from the test units were only slightly higher than in that from a control unit receiving the normal OPE_{10} concn. of 4.5 ppm. There was no problem with foaming in the aerators and no redn. in efficiency of treatment. Acclimation was more rapid in the field test than in the lab. tests and more rapid in a continuous lab. unit than in a semicontinuous unit.

Degradation of OPE_{10} also occurs readily in river water.

BIODEGRADABLE NONIONIC SURFACTANTS IN TEXTILE WET PROCESSING, B. B. Rein (Continental Oil Co.), Am. Dyestuff Reptr. 56: 909-915, (Nov. 1967).

The purpose of this article is to show, in tests widely accepted by the textile industry, that biodegradable surfactants are at least as efficient, and, in many instances, more efficient than the current nonbiodegradable surfactants.

BIODEGRADATION OF SURFACTANT BENZENE RINGS, Swisher, Robert D. (Inorg. Chem. Div., Monsanto Co., St. Louis, Mo.), Ind. Chim. Belge, (1967), 32 (Spec. No.), 719-22.

A linear alkylbenzenesulfonate (I) was prepd. by alkylation of benzene with α-dodecane to give a mixt. of 2-, 3-, 4-, 5-, and 6-phenyldodecane, which was then sulfonated and converted to the Na salt. Detergent concns. were detd. by a modified methylene blue test. Benzene and derivs. were detd. from absorption intensities at 180, 200, and 256 m with river water in the reference cell. Plots of methylene blue response over periods of 10-20 days, and uv spectra at 0, 10 and 44 days are given. Based on the progressive disappearance of the peak at 223 m it is concluded that the benzene ring of the I structure is destroyed during the biodegradation process.

THE DEVELOPMENT OF BIODEGRADABLE SURFACTANTS AS AN ANSWER TO A WATER POLLUTION PROBLEM, E. C. Steinle (Union Carbide Corp.), Am. Dyestuff Reptr. 56: P386-P390, (May 1967).

Wastes, waste disposal, types of pollution, and surfactant pollution are discussed briefly, biodegradability (what it is, how it is measured) and the characteristics of commercially available biodegradable surfactants are examined in detail.

UNION CARBIDE'S BIODEGRADABLE SURFACTANTS FIGHT POLLUTION, Am. Textile Reptr., 80, (25), p. 60, (1966).

Union Carbide's biodegradable surfactants for the textile industry are discussed in relation to water pollution.

BIODEGRADATION TESTING OF TYPICAL SURFACTANTS IN INDUSTRIAL USAGE, Richard A. Conway and Gene T. Waggy (Union Carbide Corp., S. Charleston, W. Va.), Am. Dyestuff Reptr. 55 (16), 607-614, (1966).

Susceptibility of surfactants to bacterial oxidn. in industrial waste water treatment plants and surface waters can be monitored by simple screening tests, such as shake-culture, activated sludge, and river die-away. Detailed comparisons of linear secondary-alc. ethoxamers with alkylphenol-based surfactants were made by several test procedures. The linear secondary-alc. ethoxylates were efficiently biodegraded under a range of environmental conditions, while the alkylphenol materials have not as yet been demonstrated to meet these degradation standards.

RELATIONSHIP AMONG "EMULSION" TYPE, DETERGENCY, AND FOAM, W. R. Kelly (Allied Chem. Corp.), J. Am. Oil Chemists Soc. 43: 358-363, (June 1966).

Three test methods were developed to show the measurably close relationship existing among detergency, foam, and the indication of the type of "emulsion" naturally inclined to form. Visual recognition of the state of the emulsion makes it possible to assess the system as to its comparative detergent capabilities and its foaming proclivities. Guided steps can then be taken for improvements. The methods have been used with success in formulating alkaline cleaning mixtures.

FOAM TEST METHOD, W. R. Kelly and P. F. Borza (Allied Chem. Corp.), J. Am. Oil Chemists Soc. 43: 364-365, (June 1966).

This method measures the height of foam developed by pouring. The action is intermittent, time being alloted strictly for foam decay, as well as for foam generation.

SYNTHETIC DETERGENTS-THEIR INFLUENCE UPON Fe-BINDING COMPLEXES OF NATURAL WATERS, Fred Kent and Frank F. Hooper (Univ. Museums Annex, Ann Arbor, Mich.), Science 153 (3735), 526-7, (1966), (English).

Most of the org. exts. prepd. from Michigan lakes and streams exhibited Fe-binding capacity, land increased the growth rate of Chamydomonas reinhardi. Histidine, tyrosine, and aspartic and glutamic acids were abundant in these exts. Samples collected from the Huron River on 19 April 1965 failed to show the reaction; analysis indicated the presence of anionic detergents. In samples failing to bind Fe, alkylbenzenesulfonates were bound to the amino acids.

THE ORIGIN, BEHAVIOR AND REMOVAL OF PHOSPHATES FROM SURFACE

WATER AND WASTE WATER. PART 2., M. Kehren; A. ges. Textil-Ind. 68, No. 10: 782-788, (1966), (German) Through Shirley Inst. 46: 5938, (1966).

> This review gives details of electrolytic phosphate precipitation techniques referred to in Part 1. Other techniques, notably precipitation with aluminum sulfate, are surveyed. There is a review of the analytical methods used for phosphate determination. The methods are (1) Molybdenum Blue method and (2) paper-chromatographic separations.

CHEMICAL PURIFICATION OF WASTE WATERS FROM SYNTHETIC ANION SURFACE-ACTIVE SUBSTANCES, Yu. Yu Lur'e and P. S. Antipova; Vodosnabzh. Sanit. Tekh., (1966), (11), 18-20, (Russian).

> The method introduces into waste waters contg. synthetic suffactangs, grease, impurities, and the K salt of various org. acids, as well as sorbents which keep up their properties at high pH values, such as $Ca(A10_2)_2$, MgO, and calcined or semicalcined dolomote. It was found possible to obtain the necessary amt. of efficient absorbent by introducing $AlCl_3$ or $Al_2(SO_4)_3$, MgO, or dolomite as well as a certain amt. of milk of lime (pH 12-12.4) directly into the water being purified.

DEGRADABLE POLLUTANTS-STUDY OF THE NEW DETERGENTS, McGauhey, Percy, H.; Klein, Stephen A. (Univ. of California, Berkeley, Calif.), Advan. Water Pollut. Res., Proc. Int. Conf., 3rd, (1966), (Pub. 1967), 1, 353-74.

> Pilot plant studies of the degradable detergent LAS (linear alkylate sulfonate) indicated that secondary sewage treatment was necessary if frothing was to be precluded. Monitoring studies of 2 treating plants during the changeover from ABS (alkylbenzenesulfonate) to LAS confirmed the pilot plant studies that a high degree of waste treatment was still required to prevent frothing of the receiving water.

RAPID METHOD TO TEST/SOAPS SYNDETS, B. M. Milwidsky and S. Holtzmann; Soap Chem. Specialties 42: 83-86, 154-158, (May 1966).

> The two-phase titration method described permits easy, fast, and accurate determination of anionic detergents, both soap and synthetic, and ready differentiation between the two in mixtures.

REMOVAL OF DETERGENTS FROM WATER, Odom, James J.; Shumaker, Thomas P.; Bloomquist, Paul R. (Reichhold Chemicals, Inc.), S. African 67 06, 339, 27 Feb. 1968, U. S. Appl., (02 Nov. 1966).

Removal of both alkylbenzenesulfonate (hard) detergents and linear alkyl sulfonate (soft) detergents from waste water systems is accomplished by treating the waters with a water-sol., cationic, amine-contg. synthetic resin. The amine-contg. resinous removal agents react with the detergents to produce insol. reaction products which can be readily removed from the water by conventional clarification means such as filtration, settling, and decantation. Amine-aldehyde resins contg. reactive amine groups are preferred such as polyamine-modified urea-formaldehyde and melamine-formaldehyde resins. A principle advantage of the resins is that both hard and soft detergents are removed through their use.

A SIMPLIFIED TECHNIQUE FOR ROUTINE ANALYSIS OF ANIONIC DETERGENTS IN WATER AND WASTE-WATER, J. F. Panowitz and C. E. Renn, J. Water Pollution Control Fed. 38: 636-640, (Apr. 1966).

REMOVAL OF ALKYLBENZENESULFONATES (ABS) FROM WATER, Jer-Yu Shange (to Sun Oil Co.), U. S. 3,247,103, (Cl. 210-21), (April 19, 1966), Appl. Dec. 3, 1962.

In this process, water contg. ABS is mixed with an immiscible org. liquid. The ABS collects at the interface between the immiscible liquids with the sulfonate portion in the water and the org. portion in the org. liquid phase. ABS was concd. at the interface and scpd. from the water phase by one of several convenient methods, thus reducing the ABS concn. of the water.

FOAMING OF SOLUTIONS OF SURFACE ACTIVE AGENTS, M. G. Shikher, Z. P. Ezhova, N. P. Belova, and L. A. Rybina; Tekstil. Prom. 26, No. 7: 55-57, (1966), (Russian) Through Shirley Inst. 46: 4864, (1966).

To characterize the foaming capacity of a solution of a surface active agent, an index determined from the area bounded the curve obtained by plotting relative foam-height against time has been used. Values of this index have been obtained for a number of surface active agents, with and without foam suppressors, and it is shown that, in some cases, foaming can be reduced by mixing two surface active agents.

AN AUTOMATIC METHOD FOR THE DETERMINATION OF ANIONIC SURFACE-ACTIVE MATERIAL IN WATER, A. Sodergren; Analyst 91: 113-118, (Feb. 1966) Through Shirley Inst. 46: 2195, (1966).

An automatic version of the Methylene Blue procedure for determining alkylbenzenesulfonates in fresh and saline waters, by means of the Technicon AutoAnalyser, is described.

DISPOSAL OF INDUSTRIAL EFFLUENTS, B. A. Southgate; Specialties 2(12), 29-32 (1966).

For the activated-sludge process, settled sewage is treated in tanks. This process suffers from under-aeration and is sensitive to anything that reduces the concn. of O in soln. Detergents and many industrial effluents contg. substances such as phenol, oils, and cyanides have a deleterious effect on O absorption and bacterial action. Changes in the type of detergents have become necessary. However, the new detergents are biodegradable only under aerobic conditions. They interfere with anaerobic fermentation and are as undegradable as the "hard" surfactants originally used. Industrial wastes must be closely controlled as to biodegradability. Some effluents may require sep. and special treatment.

IDENTIFICATION AND ESTIMATION OF LAS (linear Alkylate sulfonates) IN WATERS AND EFFLUENTS, R. D. Swisher (Monsanto Co., St. Louis, Mo.), J. Am. Oil Chemists' Soc. 43(3), 137-40, (1966).

A sample contg. about 1 mg. of methylene blue active substance (Standard Methods for Examination of Water and Waste Water, New York: Am. Publ. Health Assoc., 1960, 11th ed., p. 245-51) and 150 ml. of the methylene blue reagent are shaken with 50 ml. $CHCl_3$, the $CHCl_3$ and emulsion layer is forced through a 2-cm. bed of glass wool in a 2-cm. diam. tube, the $CHCl_3$ layer is sepd., the original aq. mixt. is again extd. with 50 ml. of $CHCl_3$, the combined $CHCl_3$ layers are evapd., and the residue is desulfonated and gas chromatographed. Gas chromatographs of samples and effluent to which 0.5 ppm. LAS has been added are presented and interpreted.

FOAM--AN APPLICATIONAL PROBLEM, H. E. Tschakert. Tenside 3: 317-322, (Sept. 1966); 359-365, (Oct. 1966); 388-394, (Nov. 1966); (German), English translation in Tenside 3: 49-52, (Sept. 1966); 59-62, (Oct. 1966); 67-70, (Nov. 1966).

Part 1 discusses foam formation and its breakdown, as well as methods of determining foam. Part 2 deals with further methods of foam determination and contains examples of the practical utilization of foam characteristics of surface active substances, soaps, and active detergent blends. Part 3 discusses the biodegradation of surfactants.

EFFECT OF SURFACTANTS ON THE BIOCHEMICAL PURIFICATION OF WASTE WATERS, S. V. Yakovlev, Yu. M. Laskov, T. A. Karyukhina, Yu. V. Voronov, and M. S. Lebedovskii, (V. V. Kibyshev Inst. of Architecture Eng., Moscow), Izv. Nyssh. Ucheb. Zaved., Stroit. Arkhitekh, 9(8), 124-32, (1966), (Russian).

> The surfactants OP-7, OP-10, and B-A which are polyethylene glycol derivs. of the mixt. of long chain mono- and dialkylphenols, and nonionic or cationic surfactants, resp., can be biol. degraded in wastes if their concn. does not exceed 20 mg./1. Compound 101, a long-chain quaternary alkylamidomethylpyridinium salt, should not be allowed in waste drainage systems.

BIODEGRADABLE DETERGENTS FOR THE TEXTILE INDUSTRY, R. L. Huddleston (Continental Oil Co.), Am. Dyestuff Reptr. 55: P52-P54, (Jan. 1966).

> Although biodegradable detergents by their very nature must have a BOD, studies indicated that straight chain alcohol nonionic products should not noticeably affect total BOD requirements of textile plant effluent waters.

KNIT GOODS FINISHERS AND BIODEGRADABLE DETERGENTS, R. H. Beaumont (W. F. Fancourt Co.), Knitting Ind. 85: 10, 39, (Nov. 1965).

> If waste goes through a treatment system, the new detergents are desirable; if not, it may be better to keep biodegradability to a minimum.

REMOVAL OF NONBIODEGRADABLE DETERGENTS FROM SEWAGE, Herbert N. Dunning, Maurice M. Kreevoy, and James M. White (to General Mills, Inc.), U. S. 3,215,622 (Cl. 210-21), (Nov. 1965), Appl. April 26, 1961 and Nov. 2, 1965, 8 pp.

> Nonbiodegradable detergent residues are removed from sewage with 90-98% efficiency if the sewage is acidified, stirred with kerosene contg. a long-chain, water-insol. secondary amine, and the org. phase is stripped. The sepd. org. phase is scrubbed with caustic to recover reuseable material. Ca(OH) , NaOH, Ba(OH) are all suitable caustic strippers for regeneration of the amone.

WATER AND WASTE WATER. PART 2., M. Kehren, Z. ges. Textil-Ind. 67, No. 10: 807-811 (1965), (German) Through Shirley Inst. 45: 5681, (1965).

This article supplements information on the biodegradability of detergents and surface active agents given in abstr.

RATES OF DECOMPOSITION IN NATURAL WATERS OF SOME SYNTHETIC DETERGENTS AND SURFACE-ACTIVE SUBSTANCES, V. P. Kaplin, N. G. Fesenko, A. I. Fomina, and L. S. Zhuravieva; Nauch. Tr., Akad. Kommunal. Khoz. No. 37, 97-110, (1965), (Russian).

Synthetic detergents of the alkyl sulfate type decomp. in natural waters relatively quickly (48-480 hrs.); alkylsulfonates decomp. more slowly 10-50 days), and alkylarenesulfonates extremely slowly (30-90 days). The decompn. time is greatly affected by the initial concn. of detergents. The decompn. time is longer at higher initial concn. Abs. quantity of decompd. detergent increases also with increased initial concn. Decompn. of synthetic surface-active substances is affected by the chem. structure: e.g. dodecyibenzenesulfonate with straight alkyl side chain decomp. 2-3 times more quickly than the same prepn. with a branched alkyl side chain.

INFLUENCE OF DETERGENTS ON WATER ALGAE, D. Matulova; Sb. Vysoke Skoly Chem.-Technol. Praze, Technol. Vody 8(2), 251-301, (1965), (English).

The effect of detergents, made in Czechoslovakia, on water algae was tested. Chlamydomonas gelatinosa was more sensitive than Scenedesmus abundans and Chlorella saccharophila. Unfavorable effects were observed with 9 mg./1. of alkylsulfates, 7 mg./1. of alkylbenzenesulfonates, 0.1 mg./1. of cetylpyridinium bromide, 25 mg./1. of diisobutylnaphthalenesulfonate, and 5 mg./1. of non-ionic surfactant (cetyloeyl alc. + 20 mols. ethylene oxide). The lethal concns. were 111, 70, 2, 200, and 200 mg./1., resp.

SURFACE-ACTIVE AGENTS IN WASTE WATERS. VIII. RELATIONSHIP BETWEEN MOLECULAR STRUCTURE AND THE SUSCEPTIBILITY OF ANION-ACTIVE SURFACTANTS TO BIOCHEMICAL OXIDATION (summary of the results), P. Pitter; Sb. Vysoke Skoly Chem.-Technol. Praze, Technol. Vody 8(2), 13-39, (1965).

Branched alkyl chains reduce the decompn. of alkylarenesulfonates and alkyl sulfates by activated sludge. Some iso-alkyl sulfates are biol. - not fully oxidized, being probably resistant to total biol. hydrolysis. Sulfated N-(hydroxyalkyl) amides of high-mol.-wt. fatty acids and sulfated low-mol.-wt. polyethylene glycol n-alkyl ethers (sulfated nonionic surfactants) are biol.

easily oxidized. Alkanesulfonates with straight alkyl chains are readily biol. degraded. The behavior of n-alkyl touenesulfonates is similar to that of n-alkyl benzenesulfonates. Both are utilized less as a source of org. C by microorganisms than n-alkyl sulfates. The studies made possible a classification into 3 classes: (1) Soft surfactants easily biodegradable, n-alkyl sulfates, n-alkane sulfonates, sulfated low- mole.-wt. polyethylene glycol n-alkyl ethers, sulfated N- (hydroxyalkyl) amides of high-mol.-wt. fatty acids and others; (2) semihard surfactants biol. slowly or semidegradable, n-alkyl benzenesulfonates, n-alkyl toluenesulfonates and mixts. of soft and hard surfactants, and their admissible concn. for sewage treatment must be detd. expt.; (3) hard surfactants hardly degradable, isoalkylarenesulfonates, and isoalkyl sulfates.

THE BIODEGRADABILITY OF TEXTILE AUXILIARIES, Salquain, J.; Teintex, 30, (4), p. 233-259, (1965), (French).

This study of the behaviour of most classes of surface-active agents in biological effluent purification also includes notes on current legislation in Europe.

A PROCEDURE AND STANDARDS FOR THE DETERMINATION OF THE BIODEGRADABILITY OF ALKYLBENZENESULFONATE AND LINEAR ALKYLATE SULFONATE, C. M. Snow, et. al.; J. Am. Oil Chemists' Soc. 42(11), 986-93, (1965).

The procedure designed is based on screening by the simple "Shake flask method" (A) and as a confirming phase, the more complex and tedious semicontinuous activated sludge procedure (B). According to the standard established, a 90% biodegradability in A is adequate; a value of 80-90% biodegradability in A requires detn. by B. A result below 80% indicates not adequately biodegradable.

ACCURACY AND PRECISION OF LABORATORY AND FIELD METHODS FOR THE DETERMINATION OF DETERGENTS IN WATER, C. H. Wayman and A. T. Miesch, (U. S. Geol. Surv., Denver, Colo.), Water Resources Res. 1(4), 471-6, (1965).

The results obtained by using the 2 field methods and the lab. method currently employed for the detn. of both the branched-chain and straight-chain alkylbenzenesulfonates in water are recorded and evaluated on the basis of accuracy and precision. Field method (1) employs a modified methylene blue technique, and field method (2) employs the dye Toluidine Blue O as the complexing agent. The lab. method (3) employs methylene blue as the complexing agent. Method (2) showed relatively large and statistically significant amts. of neg. bias that varies with the concn. level with both types of detergent. The precision of method (2) was slightly poorer than that of method (1), and considerably poorer than that of method (3).

REMOVAL OF ANIONIC SURFACTANTS FROM LIQUIDS, Irving M. Abrams (to Diamond Alkali Co.), U. S. 3,232,867 (Cl. 210-37), Feb. 1, 1966, Appl. (Aug. 1963), Continuation-in-part of U. S. 3,123,553.

The removal of alkylbenzenesulfonates (I) in amts. of 1-10 pom. is accomplished by passing the liquid through a weak-base anion-exchange resin in the acid-salt form, II. II has a greater capacity for absorbing I and other detergent anions than did a resin in the tree or hydroxide form. The absorbed I can be quant. recovered by elution with aqueous alkali. In the treatment of sewage effluent by this process, it is necessary to first clarify the effluent before anion-exchange treatment. Numerous resins are available for this use. A resin like Duolite A-7 was found to absorb about four times as much I per g. as did activated C.

WATER TREATMENT FOR USE

INDUSTRIAL WATER AND ITS SIGNIFICANCE IN THE FINISHING OF KNITTED GOODS, H. Gunter. Wirkerel-u. Strickerei-Tech. 18, No. 10: 531-538 (1968). (German) Through World Textile Abstr. 1: 847 (1969).

> Methods used for expressing the hardness of process feed water in Germany, France, and the U. K. are explained. The effects of hardness and the presence of iron, manganese, and copper salts or organic impurities in bleaching, scouring, and dyeing are discussed. Tables give some maximum permissible concentrations for the different processes. Methods of water conditioning and water requirements for different types of knitted goods are considered briefly.

WATER TREATMENT IN TEXTILE MILLS, R. Oncellet. Textil-Praxis 24, No. 2: 104-108 (1969). (German) Through World Textile Abstr. 1: 1604 (1969).

> Water treatment equipment by the firm of Hager and Elsasser is described and illustrated. The sections of the article deal briefly with filtration of suspended matter, removal of iron and manganese, deacidification, softening and desalination, treatment with special phosphates, and degasification.

PREPARATION OF PROCESS WATER FOR THE TEXTILE INDUSTRY, F. Rub. Chemiefasern 19, No. 1: 58-61 (1969). (German) Through World Abstr. 1: 1332 (1969).

> This article deals in particular with the application of ion-exchangers for the purification of textile process water. These are used where comparatively small volumes of water of a very high degree of purity are required. Boiler feed water for small rapid steam raising equipment is a case in point. Ion-exchange equipment by eight West German manufacturers is described and illustrated. There is a short comment on test equipment for the continuous monitoring of water quality.

IMPROVED WATER QUALITY, R. J. Mattson and V. J. Tomsic (E. I. du Pont de Nemours & Co.). Chem. Eng. Progr. 65: 62-68 (Jan. 1969).

> The authors state that the technology and equipment for providing water of improved quality from specific brackish water sources are available. They describe a new separator, the Permasep permeator,

which, using nylon hollow fibers in a reverse osmosis operation, promises to be a novel approach in upgrading water for process and municipal use. The results of field tests are reported.

PROCESS WATER AND TEXTILE EFFLUENT PROBLEMS. PART 2., F. H. Slade. Textile Mfg. 94: 89-93, 99 (Mar. 1968).

Biological treatment of effluent, oxygen transfer, continuous sludge removal, flocculation, difficult wastes, and the Lubeck process are considered.

MANGANESE IN PROCESS WATER OF THE TEXTILE INDUSTRY. R. S. Ingols. Tribune CEBEDEAU 20:271-272 (1966). (French) Through Chem. Abstr. 66, No. 6: 19673 (1967).

Hazards arising in textile plants from the presence, usually seasonal, of manganese in surface water used as a water supply are discussed. Accumulated deposits of manganese oxides in heat exchangers and distribution systems can be released by pressure surges and result in staining of white cloth and in shade changes in some dyes. Five methods of treating the water supply are suggested.

TREATMENT OF PROCESS WATER, WITH REFERENCE TO SPECIAL PHOSPHATES, L. Mattes. Spinner Weber Textilveredlung 85, No. 2: 120-122 (1967). (German) Through Shirley Inst. 47: 1571 (1967).

The suppression of lime deposits by metal phosphates and the solubilization of iron by silica-phosphate (Siliphos) are discussed.

WATER FOR THE DYER, T. H. Morton (Courtaulds Ltd.). J. Soc. Dyers Colourists 83: 177-184 (May 1967).

The present and estimated future use of water in England and Wales is compared with available resources. The quality of water for use in the dyeworks is discussed in terms of dissolved and suspended impurities; and the methods available for the control of the effects on the dyeing process of ionic solutes, residual hardness, heavy metals, and bicarbonate are summarized. The problems of disposal of dyeworks' effluent are also considered.

TREATMENT OF PROCESS WATER, F. Rub. Chemiefasern 17, No. 2: 140-146 (1967). (German) Through Shirley Inst. 47: 1281 (1967).

Filtration and softening plant by German manufacturers is reviewed.

INDUSTRIAL WATER SOFTENING, S. H. Qasim. Pakistan Textile J., 18, P. 27-30, (1967).

Commercial methods of conditioning boiler water via the lime soda, ion exchange and metaphosphate processes are discussed. The article includes a brief description of methods generally used in softening process water especially in the textile industry.

IMPORTANCE OF PH CONTROL IN THE AUTOMATION OF A WATER SOFTENING PLANT, E. Wedlich. Textil-Praxis 22, No. 8: 586-590 (1967). (German) Through Shirley Inst. 47: 449 (1967).

It is demonstrated the equipment for the rapid removal of carbonate hardness can be automated. The system described has three reactors and a pH controller which regulates the addition of milk of lime (calcium hydroxide). The control equipment is by Polymetron AG.

THE ORGANIZATION AND PROBLEMS OF A COMMERCIAL WATER AND EFFLUENT UNDERTAKING. PART 2. ION-EXCHANGERS IN WATER TREATMENT, J. Wilhelm. Spinner Weber Textilveredlung 85, No. 2: 122-123 (1967). (German) Through Shirley Inst. 47: 1572 (1967).

This article contains a list of names of useful ion-exchangers produced in Europe and America.

PROCESS WATER FOR THE TEXTILE INDUSTRY, W. Pree. Melliand Textilber. 47, No. 1: 89-92 (1966). (German) Through Shirley Inst. 46: 1132 (1966).

This brief survey of the necessity of water treatment and possible methods covers deacidification, iron and manganese removal, softening, and partial and full de-salting.

REMOVAL OF IRON AND MANGANESE FROM RAW WATER SUPPLIES, R. L. Reed (Betz Labs.). Betz Indicator 35: 2-7 (Mar. 1966).

These impurities can be removed from water by several different processes and combinations of processes. Careful study is required to select a method most suitable to any individual case.

WATER TREATMENT WITH PHOSPHATES, R. Wagerle and J. A. Benckiser. Textil-Praxis 21, No. 1: 36-39 (1966). (German) Through Shirley Inst. 46: 1375 (1966).

> The phosphate inoculation of water feed systems is discussed: this prevents lime deposits and inhibits corrosion. Boiler feed water is prepared or adjusted by phosphate additions.

WATER TREATMENT DATA: A HANDBOOK FOR CHEMISTS AND ENGINEERS IN INDUSTRY, W. M. T. Body and G. S. Solt. Hutchinson & Co. Ltd., London. 1965. 60 p. Available from Chemical Rubber Co., 2310 Superior Ave., Cleveland 14, Ohio.

> Contents: General and engineering data, Properties of solutions, Chemical and process data, Costs.

INSTRUMENTATION AND PLANT DESIGN FOR WASTE TREATMENT

CLEANING OUR ENVIRONMENT: THE CHEMICAL BASIS FOR ACTION, ACS Subcomm. on Environmental Improvement, Am. Chem. Soc. Special Issues Sales, 1155 16th St. N. W., Washington, D. C. 20036. (1969).

> Although this report does not contain specific information on textile waste control it does contain valuable material on solid waste control, air pollution, and water pollution in general.

POLLUTION CONTROL DIRECTORY, Environmental Sci. & Technol. 3: 951-1130, (Oct. 1969).

> This directory is divided into the following sections: (a) Advertised product directory; (b) Professional consulting services; (c) Products, services, and supplies; (d) Events calendar; (e) Trade names; (f) Books and authors; (g) Company directory.

THE TREATMENT OF INDUSTRIAL WASTES, E. B. Besselievre (Forrest & Cotton, Inc.), McGraw-Hill, New York, (1969).

> Introduction; Selecting an engineer; The problems - the requirements; The information - the data - the characteristics; The study; The design; Construction and the operation; Conventional and unconventional methods of treatment of industrial wastes; The role of the federal government in water pollution and its wastes; Ordinances and regulations; Designing economy into industrial wastes treatment; Sludge; Coagulants and aids; Incentives to industry; Renovation of industrial waste effluents for reuse.

ENVIRONMENTAL POLLUTION INSTRUMENTATION, R. L. Chapman, ed. (Instrument Soc. of America), Instrument Soc. of America, 530 William Penn Place, Pittsburgh, Pennsylvania, 15219, (1969).

> This book contains selected papers from symposia presented under the auspices of the Analysis Instrumentation Division of the Instrument Society of America. The following may be of some textile interest: (1) Instrumentation for monitoring air pollutants, by A. P. Altshuller; (2) Meterological instrumentation for air pollution applications, by H. E. Cramer; (3) Calibration of SO_2 monitoring instruments, by T. A. Gray and E.R. Kuczynski; (4) The future of instrumentation in water pollution control, by J. H.

McDermott, D. G. Ballinger, and W. T. Sayers; (5) Total organic carbon analysis and its relationship to biochemical and chemical oxygen demand, by R. H. Jones; (6) A stink in the ear: noise, by H. C. Roberts.

ECONOMICS OF WASTEWATER TREATMENT, W. W. Eckenfelder, Jr. and D. L. Ford; Chem. Eng. 76: 109-118, (Aug. 1969).

Treatment processes and related capital costs for wastewater treatment from process industries are discussed. Mathematical models of various processes as well as an optimization approach to wastewater treatment, based on volume flow and effluent quality, are included.

BOOK OF ASTM STANDARDS. PART 23. WATER: ATMOSPHERIC ANALYSIS, Am. Soc. for Testing & Materials, 1916 Race St., Phila., Pa., 19103, (Oct. 1968).

DIRECTORY OF GOVERNMENT PERSONNEL IN WATER SUPPLY AND POLLUTION CONTROL, Water & Wastes Eng. 5: 34-42, (Jan. 1968).

Names, addresses, and officers of the federal, state, and interstate agencies governing the various aspects of water supply and pollution control are listed.

ENVIRONMENTAL ENGINEERING - A COMPLETE GUIDE TO POLLUTION CONTROL, Chem. Eng. 75, No. 22, (Oct. 1968).

This special issue contains information on governmental control activities, state air and waters laws, how to organize a control program, the technology of abatement, 100 types of equipment, 900 equipment suppliers, and 300 technical bulletins. The major sections are classified under the headings (1) The challenge of pollution control, p. 13-52; (2) Water pollution control, p. 73-117; (3) Air pollution control, p. 141-169, refs.

WATER AND ITS PROBLEMS, G. Digout, Teintex 33, No. 3: 155-167, (1968), (French) Through Shirley Inst. 48: 2515, (1968).

The organization of water conservancy boards in France is explained. A National Water Committee has been formed. Purification of water effluent from dyeworks is discussed in general terms. Specific problems of sulfides and detergents are referred to.

SOLUTION TO WATER POLLUTION SEEN IN JOINT ACTION, T. M. Forbes, Am. Textile Reptr. 82: 25, 49-50, (Aug. 1968).

The author defines the six major types of water pollution that are covered by statutory laws and administrative regulations and he suggests that industry, through knowledge of the law and with the help and guidance of public government agencies, can eventually improve the quality of water before and after use.

INDUSTRIAL WASTE TREATMENT MANAGEMENT, R. N. Rickles and R. W. Okey (Resources Engineering Assoc.), Water & Wastes Eng. 5: 14-18, (Sept. 1968).

This paper covers the following areas of waste treatment:
(a) Organization of a corporate waste treatment program;
(b) Organization of an industrial waste treatment project;
(c) Design of operable industrial waste treatment facilities;
(d) Design of biological waste treatment facilities based on contacting modes other than completely mixed systems.

COST OF CONVENTIONAL AND ADVANCED TREATMENT OF WASTEWATER, R. Smith (Cincinnati Water Research Lab.), J. Water Pollution Control Fec. 40: 1546-1574, (Sept. 1968).

Most of the information in this comprehensive article is in the form of tables (9) and figures (29).

THE POLLUTION PROBLEM, J. M. Stepp and H. H. Macaulay (Clemson University), American Enterprise Inst. for Public Policy Research, 1200 17th St., N. W. Washington, D. C., 20036, (Oct. 1968).

Contents: (1) Introduction; (2) Economic nature of the problem; (3) Some possible side effects of pollution control; (4) Criteria for classifying various kinds of pollution; (5) Trends in pollution control in the U. S.; (6) Economic effects of various kinds of pollution controls; (7) Philosophy of pollution control.

AUTOMATIC LIQUID SAMPLER, No. Hants Eng. Co. Brit. Hosiery J. 22: 23, 24, (Mar. 1967).

This is a description of a mechanically operated liquid sampler for obtaining samples of dyeing effluent and contaminated water.

SUMMARY OF INDUSTRIAL WASTE TREATMENT CONCEPTS AND PRACTICES, Betz Labs., Betz Indicator 36: 2-8, (July 1967); 2-8 (Aug. 1967).

This summary was prepared for those who are not actively involved in waste treatment or closely associated with the control of industrial waste water, but who seek basic information regarding current concepts and practices.

THEORY OF BIOLOGICAL TREATMENT OF TRADE WASTES, W. W. Eckenfelder, Jr., J. Water Pollution Control Fed. 39: 240-250, (Feb. 1967).

A REDUCED-SCALE METHOD FOR THE DETERMINATION OF THE DI-CHROMATE VALUE (Chemical Oxygen Demand) OF SEWAGE AND TRADE EFFLUENTS, Fearn, R. J., W. H. Hetherington, S. M. Jaeckel, and C. D. Ward; J. Soc. Dyers Colourists, 83, p. 146-151, (1967).

> A description is given of a convenient and reliable analytical method for the determination of the dichromate value of sewage and trade effluents. The method is more rapid than existing macroscale procedures and is sufficiently analytically accurate and reproducible for the calculation of trade-waste treatment charges. Oxidation with potassium dichromate is carried out in boiling 50% (vol./vol.) sulfuric acid, with a total reagent volume of 30 ml.

DESIGN OF AERATED SYSTEMS FOR INDUSTRIAL WASTE TREATMENT, J. L. Mancini and E. L. Barnhart (Hydrosciences, Inc.), J. Water Pollution Control Fed. 39: 978-986, (June 1967).

> A laboratory method which can be used to evaluate and compare activated sludge, aerobic digestion, and aerated lagoons is suggested as an aid in planning a waste treatment system.

REMOVAL OF FORMALDEHYDE FROM WASTE WATERS, Schmitz, Paul, Karl H. Krueger, Hans Havekoss, and Fritz Steinfatt; Farbenfabriken Baye A.-G. Ger. P. 1, 244, 144 (Cl. C 07c), (July 1967), Appl. Jan. 30, 1964; 3 pages.

> Acidified (pH 4) waste waters from resin manufacturers are freed of HCHO by adding MeOH and heating. One 1. of waste water contg. HCHO 4, H_2SO_4 12, HCO_2H 15%, and other org. and inorg. compounds was treated with 50 ml. MeOH and heated. During heating, another 150 ml. of MeOH was added and the vapors were removed through a small column. The residual waste water contained 0.005% HCHO and had substantially less toxicity to *Escherichia coli* and *Daphnia pulex*.

BIOCHEMICAL DECOMPOSITION OF ANILINE AND SOME OF ITS DERIVATIVES, Stasiak, Miroslaw; Gax, Woda, Tech. Sanit., 41, (8), (1967), (Polish).

$PhNH_2$, m- and p-$NH_2C_6H_4OH$, p-$NH_2C_6H_4CHO$, m- and p-$NH_2C_6H_4NO_2$, o-$NH_2C_6H_4$-Cl, and p-$NH_2C_6H_4SO_3H$ were subjected to biochem. decompn. controlled by detn of concn. cf the initial compds. O, NH_3, and NO_2^-. Harmful effect of some compds. was studied by detn. of B.O.D. The highest rate of decompn. was observed in $PhNH_2$ and p-amino-benzaldehyde. The decompn. of amino-phenols was much slower, and nitroanilines, chloro-aniline, and sulfanilic acid were not decompd. under the exptl. conditions. Nitroanilines and sulfanilic acid inhibited the self-purification of anilines.

CELANESE DEEP WELL DISPOSAL PRACTICES, Veir, Byron B.; Ind., Water Waste Conf., Proc., 7th, Austin, Tex., p. III-25 - III-36, (1967).

Plant waste characteristics, lab. testing of wastes, selection of a waste disposal system, and waste treatment are discussed. The treatment system consists of a waste neutralization tank, a gravity settling tank, filter feed pumps, Anthrafilt bed filters, cartridge filters, and a high-pressure injection pump. A 200-ft. blanket of highly permeable sand strata located at a depth of approx. 3500 ft. is suitable for deep well waste disposal. Results of the study indicate that deep well disposal is feasible for the plant.

REVIEW OF THE LITERATURE OF 1966 ON WASTE-WATER AND WATER POLLUTION CONTROL, C. M. Weiss and others; J. Water Pollution Control Fed. 39: 689-749, (May 1967); 867-945, (June 1967); 1049-1154 (July 1967).

Includes: Analytical methods, textile wastes.

COORDINATED EFFORT IS REQUIRED TO SOLVE PROBLEMS OF POLLUTION, M. A. Wright; Am. Textile Reptr. 81: 29-31, (Jan. 1967).

Action by business and by government on air and water pollution are discussed.

1966 BOOK OF ASTM STANDARDS. PART 23. INDUSTRIAL WATER: ATMOSPHERIC ANALYSIS, Am. Soc. for Testing and Materials, 1916 Race St., Philadelphia, Pa., 19103, (1966).

ASTM standards relating to industrial water, industrial waste water, and atmospheric analysis are included.

EFFLUENT ANALYSIS, Proc. Soc. Anal. Chem. 3, No. 2: 21-23, (1966) Through Shirley Inst. 46: 2194, (1966).

Summaries of the following papers are presented: Examples of the use of empirical methods in the analysis of complicated effluents, by F. G. Broughall; Determination of some inorganic constituents of trade effluents, by N. T. Wilkinson; Determination of organic matter in sewage and trade wastes and some observations of the determination of cyanide, by S. H. Jenkins.

INDUSTRIAL WATER RE-USE, Chem. Eng. News 44: 90-100, (Mar. 1966).

Industrial water re-use methods, particularly through cooling, are discussed.

INTERNATIONAL TRADE FAIR ON EFFLUENT TECHNOLOGY IN MUNICH, Chemiefaserm 16, No. 12: 986-992, (1966), (German). Through Shirley Inst. 47: 238, (1967).

This is an illustrated commentary on an exhibition of both full-treatment installations and individual items of equipment.

CHEMICAL PURIFICATION OF VARIOUS INDUSTRIAL WASTE WATERS, W. Ballnus; Wasser, Luft, Betr. 8: 201-204, 1964, (German), (1966).

Precipitation processes for the treatment of effluent from a paper and ceramic-producing industry and a textile plant are described. The textile waste waters are effectively purified by a combination of ferrous sulfate and calcium hydroxide or by aluminum sulfate. Costs of chemicals are quoted.

BIOLOGICAL TREATMENT OF INDUSTRIAL EFFLUENTS, N. Blakebrough; Intern. Dyer 135: 909, 911, (June 1966).

The Lubeck process is described.

AUTOMATIC SAMPLING OF SEWAGE AND EFFLUENTS, J. Dean; Instrum. Eng. 4, No. 6: 124-128, (1966) Through Shirley Inst. 46: 6655, (1966).

The author discusses types of sampling (non-proportional and proportional), automatic samplers of the pump type and of the scoop type, bottling mechanisms, and portable samplers.

WATER FROM SEWAGE EFFLUENT, Eden, G. E.; Truesdale, G. A.; Wyatt, K. L. and Stennett, G. V.; Chemistry and Industry, Vol. 14, No. 36, p. 1517, (1966).

Covers water reuse for cooling as researched by the British Water

Pollution Research Laboratory.

INDUSTRIAL MEASURES FOR THE PURIFICATION OF AIR AND WATER, M. Kehren; Textilveredlung 1, No. 5: 219-227, (1966), (German) Through Shirley Inst. 46: 3501, (1966).

> The large-scale developments and the plant at Farbwerke Hoechst are described. Mechanical diltration and electrostatic precipitation are used in air cleaners. A pilot-scale water treatment plant has been used to develop a full-scale effluent and water plant dealing with 24,000 m^3 per day.

SOLUBLE ORGANIC CHEMICAL WASTES: CONTROL, TREATMENT, DISPOSAL, Manufacturing Chemists Assoc., 1825 Connecticut Ave. N.W., Washington, D. C. 20009, (April 1966).

> This manual discusses the water pollution aspects of soluble organic chemical wastes and their control, treatment and disposal.

RECENT DEVELOPMENTS IN THE FEDERAL WATER POLLUTION CONTROL PROGRAM, S. Megregian; (Federal Water Pollution Control Admin.), Am. Dyestuff Reptr. 55: P573-576, (July 1966).

PROCEEDINGS OF THE 21st INDUSTRIAL WASTE CONFERENCE, (May 1966), PARTS 1 AND 2, Sponsored by Purdue Univ., Lafayette, Ind. n. d. 1017 p.

> (1) Biological treatment of waste water from synthetic resin manufacture, by K. G. Singleton (CIBA (A.R.L.) Ltd.), p. 62-71; (2) Mechanism of starch removal in activated sludge process, by S. K. Banerji, B. B. Ewing, R. S. Engelbrecht, and R. E. Speece, p. 84-102; (3) Sodium hydroxide recovery in the textile industry, by C. S. Carrique and L. U. Jaurequi (Univ. of Buenos Aires), p. 861-868; (4) Utilization of resistant proteins (e. g. keratine) by activated sludge, by G. J. Capestany (Municipality of Metropolitan Seattle) and D. A. Carison (Univ. of Washington), p. 943-952.

TECHNICAL BASES FOR ASSESSING THE STRENGTH, CHARGES FOR TREATMENT AND BIOLOGICAL TREATABILITY OF TRADE WASTES, J. R. Simpson; J. Appl. Chem. 16: 272-280, (Sept. 1966).

> The Public Health Act 1961 in Gt. Britain empowers a local or sewage authority to recover any additional expense incurred or

likely to be incurred in connection with the reception or disposal of trade effluents. This paper discusses technical bases for assessing these charges.

WATER: INDUSTRY CHALLENGE--TODAY, S. M. Suchecki; Textile Inds. 130: 180-110, (June 1966).

The need for industry to conserve water, use it sensibly, and use it again after suitable treatment is discussed. Dumping of untreated waste or insufficiently treated waste into streams can no longer be tolerated.

WASTE WATER AND ITS PURIFICATION WITH REFERENCE TO METHODS OF BIOLOGICAL DISINTEGRATION, J. Wilhel; Spinner Weber Textilveredlung 84, N : 145-150, (1966), (German) Through Shirley Inst. 46: 1957, (1966).

STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTE-WATER, INCLUDING BOTTOM SEDIMENTS AND SLUDGES, 12th ed. Prepared and published jointly by American Public Health Assoc., American Water Works Assoc., and Water Pollution Control Fed., American Public Health Assoc., Inc., 1790 Broadway, New York, N. Y. 10019, (1965).

WATER AND WASTE WATER. PART 1., M. Kehren, Z. ges. Textil-Industrie 67, No. 5: 361-364, (1965), (German) Through Shirley Inst. 45: 4518, (1965).

The natural cycle of water is discussed. Purification methods are summarized.

POLLUTION CONTROL 1965, R. Rickles; Noves Development Corp., Pearl River, N. Y., (1965) 207 p., Chemical Process Monograph No. 10.

Contents: Water treatment, Water renovation, Sewage disposal, Biodegradable detergents, Solids disposal, Air pollution, Radioactive waste treatment. The book discusses proven and proposed schemes for solving pollution problems.

WASTE RECOVERY AND POLLUTION ABATEMENT, R. N. Rickles (Dorr-Oliver, Inc.), Chem. Eng. 72: 133-152, (Sept. 1965).

Many waste-recovery methods have been proposed and then rejected because it is cheaper to dump the wastes (thereby polluting the streams and air) than to process them. These recovery processes will make good economic sense, however, when anti-pollution regulations prohibit dumping.

EFFLUENT PURIFICATION WITH PARTICULAR REFERENCE TO PHOSPHATE ELIMINATION, K. Wuhrmann; SVF Fachorgan Textilver. 20, No. 7: 432-441, (1965), (German) Through Shirley Inst. 45: 4520, (1965).

> Nitrogen and phosphorus are both part of the nutrient matter for microphyte organisms which multiply rapidly in effluent liquor. Methods for clearing nitrogen- and phosphorus-containing solutes from the effluent are described, and the records of one plant are discussed.

CLARIFICATION OF INDUSTRIAL WASTES BY ANAEROBIC FERMENTATION, Nevzorov, M. I., Vopr. Sovrem. Strait, i Arkhitekt Sb (USSR), 380, (1964).

> This work covers both the themophilic and mesophilic phases. The mesophilic fermentation was indicated to be best. Experiments found 25 days would reduce the B. O. D. by 90%.

APPENDIX C

Included in this appendix are listings of Textile Manufacturers and Finishers, Engineering Firms, Instrument Manufacturers, State Agencies, Schools, and Federal Agencies that contributed information for the preparation of this report.

TEXTILE AND CHEMICAL MANUFACTURERS

Abney Mills
Airco Chemicals & Plastics
American Viscose Corp.
BASF Corp.
Burlington Industries, Inc.
Calgon Corp.
Cannon Mills Co.
Celanese Corp.
Collins & Aikman Corp.
Cone Mills Corp.
Cranston Print Works Co.
Crown-Metro, Inc.
Deering Milliken, Inc.
Dow Badische Co.
E. I. du Pont de Nemours & Co., Inc.
Fiber Industries, Inc.
Gaston County Machine Works
Graniteville Co.
Greenwood Mills
Jenkins Wright Co.
Kendall Co., The
Los Angeles Piece Dye Works
M. Lowenstein & Sons
M and T Chemicals
Mohasco Industries, Inc.
National Dye & Finishing Corp.
P P G Industries
Palmetto Chemical Corp.
C. H. Patrick & Co., Inc.
Quaker Chemical Co.
Reeves Brothers Inc.
Riegel Textile Corp.
Rohm & Haas Co.
Sandoz Incorporated
Springs Mills
Standard Oil of California
J. P. Stevens & Co., Inc.
Synalloy Corp.
Tex Fi Industries
Union Carbide Corp.
United Piece Dye Works
United Merchants & Mfgs., Inc.
West Point Pepperell, Inc.
Westvaco Chemical Co.
Whitestone Chem. Corp.

ENGINEERS

Beeson Engineering Co.
Bechtel Corp.
Delta Engr. & Surveyors, Inc.
Enwright Assoc.
Eskridge & Long Construction Co.
Froehling & Robertson
    Testing Laboratory
Floyd & Davis Engineers, Inc.
Fram Corp. Industrial Div.
General Engineering Service, Inc.
Harlee-Quattlebaum Engrs.
    and Contractors
Harwood-Beebe Co., The
Lockwood-Greene Engineers, Inc.
Metcalf & Eddy, Engineers
Charles T. Main, Inc.
Palmer & Mallard Assoc.
Piatt & Davis Engr.
Piedmont Engrs. & Architects
Robert and Co. Associates
J. L. Rogers Engr. Co., Inc.
J. E. Sirrine Co.
Wiedemen & Singleton Engineers
Williams Engrs. Inc.

INSTRUMENT MANUFACTURERS

Automated Environmental Systems
Beckman Instruments, Inc.
Corning
Ionics, Inc.
Perkin-Elmer Corp.
Preiser Scientific, Inc.
Scientific Products
Union Carbide Corp.
Will Scientific, Inc.

STATE AGENCIES

Alabama
California
Connecticut
Florida
Georgia
Massachusetts
Missouri
New Hampshire
New Jersey
New York
North Carolina
Pennsylvania
Rhode Island
South Carolina
Tennessee
Texas
Virginia

SCHOOLS VISITED

Duke University
Durham, N. C.

Georgia Tech
Atlanta, Ga.

N. C. State University
Raleigh, N. C.

Philadelphia College of Textiles
& Science
Philadelphia, Pa.

Purdue University
Lafayette, Ind.

Textile Research Institute
Princeton, N. J.

Tulane University
New Orleans, La.

FEDERAL AGENCIES

Federal Water Quality Administration

APPENDIX D

EFFECTS OF FINISHING PLANT WASTES UPON WATER QUALITY

To get an idea of the waste load on several streams in the Southeast data taken from state agencies for the year 1969 is reported in Table XXIII. The analyses were made on samples taken above and below plant outfalls. In some cases a significant amount of domestic waste may be included as part of the textile waste, but this should not detract from the value of the analysis since this is a common practice in many situations. No distinction is made in the type of treatment the waste may have received before discharge. The data is reported as a qualitative reference for what was occurring in 1969.

TABLE DI

EFFECTS OF FINISHING PLANT WASTES UPON WATER QUALITY

Plant A	Water Analyses	
Parameter	Above Plant	Below Plant
Dissolved oxygen (D. O.)	6.5	5.0
Biochemical Oxygen Demand (BOD)	2.0	5.0
Coliform Bacteria (MPN)	33.0	1000
pH	6.5	6.6
Alkalinity	18	20
Color	100	200
Plant B		
D. O.	4.0	1.0
BOD	2.0	5.0
MPN	---	---
pH	6.9	7.0
Alkalinity	30	40
Color	75	200
Plant C		
D. O.	4.0	2.5
BOD	5.0	500
MPN	---	---
pH	6.8	7.7
Alkalinity	20	110
Color	50	150
Plant D		
DO	5.0	3.0
BOD	10	250
MPN	---	---
pH	6.8	11.0
Alkalinity	20	500
Color	20	70

TABLE DI (Continued)

Plant E

DO	6.5	6.0
BOD	3.0	6.0
MPN	490	650
pH	6.7	7.3
Alkalinity	20	50
Color	20	100

Plant F

DO	9.0	5.0
BOD	1-2	5.0
MPN	500	1500
pH	6.8	7.5
Alkalinity	15	70
Color	5	100

Plant G

DO	6.5	6.4
BOD	5.0	10.0
MPN	---	---
pH	6.8	4.0
Alkalinity	20	0
Color	20	100
Conductance	40 mhos/cm	1000

Plant H

DO	6.0	5.0
BOD	10.0	25
MPN	---	---
pH	6.7	7.5
Alkalinity	15	150
Color	15	100
Conductance	25	900

TABLE DI (Continued)

Plant I

DO	5.0	4.2
BOD	10.0	25
MPN	400	---
pH	6.0	7.0
Alkalinity	25	45
Color	25	50
Conductance	80	170

1 Accession Number

2 Subject Field & Group
05D

SELECTED WATER RESOURCES ABSTRACTS
INPUT TRANSACTION FORM

5 Organization
Department of Textiles; Clemson University;
Clemson, South Carolina 29631

6 Title
State of the Art of Textile Waste Treatment

10 Author(s)
Porter, John J.

16 Project Designation
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25 Identifiers (Starred First)

27 Abstract
A study has been made of waste treatment methods and practices used in the Textile industry. Information was obtained from people working in the textile processing industry, designing waste treatment plants, and enforcing state and federal regulations on waters discharged to streams and natural reservoirs. To supplement this information the literature was reviewed and an annotated bibliography prepared using relevant articles. The report contains sections on the following: characteristics of textile waste, waste treatment techniques, treatment methods in use, effects of textile wastes on receiving waters, the cost of waste treatment operations, and state and federal regulations governing discharge waters. Areas of needed research are recommended to improve waste treatment methods currently practiced by the textile industry. The report is designed to give the reader an insight into the problems facing the textile industry, solutions presently available, and references for further reading. The annotated bibliography contains references on synthetic fiber manufacturing wastes, detergent waste treatment, instrumentation, plant design, water treatment for plant use as well as articles pertaining specifically to textile waste treatment. This report was submitted in fulfillment of Grant project 12090 ECS between the Federal Water Quality Administration and Clemson University.

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